ENGINEERING

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ENGINEERING

PUBLISHED EVERY FRIDAY

Vol. 185 No. 4795 31 January 1958

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Serendipity*

MAN has created modern civilisation by making inventions. Every increase in his power to control his environment and to turn to his own advantage the resources of the rest of nature was the result of someone doing something that had not been done, and had probably not been thought of, before. It is as well to remember these facts when we arrogantly assign to our own times the title of the age of discovery or think of the last two hundred odd years as a period in which a new dimension of change has occurred in human development.

In fact we know little about the inventions of the distant past, nor of their effects on the people who benefited from them; but although there has grown up a number of generally accepted ideas about modern invention and its foster parent, research, there has been little systematic examination of the psychology of the inventor and of the social climate most conducive to his activities. In *The Sources of Invention*, a new book published this week, an attempt is made to remedy this defect. The result demonstrates the extraordinary difficulty of finding the rules by which individuals, and in particular extraordinary individuals, operate creatively.

Is science playing a part in invention it never played before? Are inventions due more to accidental discoveries than to rational planning and research? Are the big corporations and the research team taking the place of the lone inventor with limited resources, struggling against poverty, hostility and scepticism? The authors of this report, buttressed by sixty-one modern case studies, attempt to find the answers to these questions. They range from automatic transmissions through insulin to Xerography and the zip fastener; they can only remain, at the end, agnostics. Half of these inventions owed their origins to individuals outside large organisations, although many of them could not have been developed without the resources which large firms alone can provide.

The happy accident is most likely in the chemical and metallurgical fields, where a possible line of inquiry may be pursued by conducting hundreds of experiments in chemical combination, some of which provide the acute observer with unexpected but valuable lines of investigation. In engineering, on the other hand, a premeditated mechanism is more generally necessary as a basis of invention. This is a rather surprising glimpse of what should be obvious, in view of the fact that the chemical industries appear to rely so much more than others on scientific research; although most modern mechanical and electrical inventions and developments are also based on the application of theoretical knowledge.

One illusion which the authors are at pains to dispel is that the inventors of the Eighteenth and Nineteenth centuries were crude mechanics, ignorant of science. Although few of them had a scientific training, most of them had read the scientific publications which were becoming popular at the time. They frequently met scientists who took an interest in their work. This exchange between science and technology was already one of the most fruitful sources of the growth of both, and the suggestion that there is some hard and fast distinction between their methods of thought and motivation is surely unwarranted dogmatism. They both work in an environment determined by the values of the society in which they are living and will act more or less in conformity with those values according to their individual personalities. The pure scientist may work for gain or in accordance with some overall direction, while the engineer is frequently a man at odds with the world, committed only to realising an idea.

Is the growth of large-scale organisation, of government sponsored research, even of increasing university education, likely to reduce the number of inventions by increasing orthodoxy and resistance to change? The authors, who are critical of modern planning tendencies, seem to think so, but an opposite case could certainly be made out. A lot more needs to be known about the optimum size of research groups, about the way a group functions in developing ideas and about the effect on a group and on himself of a particularly gifted individual member. To condemn team-work as always a second best arrangement is surely not warranted by any known facts.

What is sure is that, however much technical advance may gain from the work of large teams working towards economic or strategic ends, there will always be individuals who prefer to work by themselves. There is no reason to believe that they will not continue to surprise a sceptical world with inventions that are strange and successful. And when they are obliged to work in a team, it may stimulate their serendipity.

* *Serendipity*—the faculty of making happy and unexpected discoveries by accident. *O.E.D.*

The Sources of Invention. By John Jewkes, David Sawers and Richard Stillerman. Macmillan and Company Limited, St. Martin's-street, London, W.C.2. (31*s.* 6*d.*)

Cover Picture. *Many firms and public utilities have to measure the acidity or alkalinity of liquids in their plant. This can be done continuously with a pH meter—basically a sensitive voltmeter equipped with special electrodes. An electronic amplifier can be used to detect the small voltages involved. The illustration shows an amplifier with an electrometer input being connected into a pH measuring system.* (*Photograph by Nurnberg*).

* * *

Plain Words

Sometimes I wonder if we are out to creep round and catch ourselves from behind. Men seem to have an inborn preference for the detour, for the roundabout route to their objectives—objectives that are frequently not the ones they had in mind. We have even discovered ways of using this idiosyncrasy to good purpose. Thus we infect ourselves with a pox virus, not because we wish to savour the rare sensation of suffering from pox, but in order to be immune from it.

Recognising this fact of life, George Bernard Shaw proposed teaching children lies and nonsense, so that in their natural contrariness and native common sense they would discover the truth for themselves. He called it the homœopathic method, but it may have been just the Irish in him.

The benefits of homœopathic reasoning have until recently been overlooked by industry, but there are now signs that the idea is catching on. At least there appears to be a tendency to do the wrong things for the right reasons. Employees of a well-known aircraft firm, for example, have made representations to the Ministry of Supply stressing that failure to award the contract for a new airliner to their company would lead to serious unemployment in their locality. Elsewhere it has been proposed that development of an unwanted fighter aircraft should be continued on similar grounds. But the British are not alone in this caprice. Litter, according to Mr. Alistair Cooke, is systematically distributed at New York Central Station to keep the refuse collectors fully occupied. I am also told, though on doubtful authority, that Liverpool Street Station is maintained in its present condition to discourage travellers and so prevent overpopulation in East Anglia.

Eventually we may arrive at a situation where production is simply a therapy for the producers, and where employment is merely a device for keeping people busy. Losing a job is not a funny matter and no one underestimates the gravity of unemployment, but to make goods that nobody wants, or when other goods are possibly preferred, can only lead to further unemployment. No doubt specialists cannot easily turn their hands to new tasks, but unless they do so, their efforts will be wasted.

For those who have polished spent cartridge cases or blancoed manhole covers, the new thinking will not seem strange. We have also become accustomed to the oblique measures used in husbanding our national resources. Soon, the indirect approach will be almost second nature. Or maybe we're just aiming off for wind.

CAPRICORN

Weekly Survey

Graving Dock for the Clyde

It has now been announced that the possibility of constructing a large graving dock with other facilities and a plant for removing oil and sludge residue from tankers is to be investigated on the Clyde. A company to be called Inchgreen Investigating Company is being formed under the chairmanship of General Sir Gordon MacMillan, chairman of the Great Harbour trustees, to examine the merits of the Great Harbour at Greenock. The company is being formed by leading shipbuilders and ship-repairers on the Clyde but the Scottish Council (Development and Industry) and certain finance houses are also going to be represented.

Reports are to be prepared on facilities including tools and cranes and also of course an estimate of the cost of the project. It appears that progress reports are likely to be issued on the company's work from time to time. The project is naturally welcomed on Clydeside and it is a great pity that a venture of this kind was not undertaken at an earlier date as had occurred on other shipbuilding estuaries. Private enterprise decided to wait for a decision on Government aid and it was not until last March that the Admiralty stated officially that it was not Government policy to help the construction of graving docks from public funds. A number of reports have come from the Clyde since then about a private venture and the main difficulty has been finance. There seems to be some indication that this problem is in process of solution. Meanwhile, the absence of a large graving dock is a serious impediment to the development of the Clyde shipbuilding and ship-repairing industry. At present large tankers have to go to the Mersey for cleaning and painting and some large ships built at Port Glasgow and Greenock have had to go to Glasgow for fitting out.

The European Trinity

Last week the Presidents of the High Authority of the European Coal and Steel Community, the Commission of the European Economic Community (which is the secretariat for the European Common Market) and the Commission of Euratom met in Luxembourg. It was agreed that there must be close collaboration among the three communities and they propose meeting at least twice a month. When the President of the European Investment Bank is appointed he will be invited to join in those discussions among the three which concern the Bank. The High Authority has offered to help in setting up the administration of the other two commissions and it seems likely that certain common services will be developed, a matter which is to be examined by a working party.

At a time when the negotiations for the Free Trade Area are heading for their most critical stage, it is important to realise the basic issue which lies behind this co-operation of the three commissions. They are very much the expression on the economic side of the urge for unity in western Europe. To the Continental mind this co-operation is part of a logical process of economic and political integration. It throws into relief the contrast between the Continental approach to these matters and the British attitude in negotiating the Free Trade Area. The British see the road ahead as a series of proposals and counter-proposals out of which some compromise arrangement will be achieved. While the British are unhurriedly and tactfully preparing a site for some economic structure which may look exceedingly untidy but be comfortable to live in, the Continental countries are rushing up an imposing edifice as an end in itself which the inhabitants will have to become accustomed to whether they like it or not. It is this difference of approach on fundamentals which has to be faced by Britain on the question of the Free Trade Area rather than dickering over agricultural tariffs and certificates of origin.

E.C.G.D. Delivers the Goods

The Export Credits Guarantee Department of the Board of Trade continued to do good business in 1957. Goods declared as shipped under E.C.G.D. cover reached the record figure of £485·4 million, a rise of over 18 per cent. compared with 1956. It is estimated that last year the proportion of goods sent abroad from this country covered by this form of insurance was nearly 15 per cent. of total British exports compared with 12·4 per cent. in the previous year. Short-term coverage remains the most important function of the E.C.G.D. There was a decline in the face value of current policies of this type from £546·6 million in 1956 to £518·6 million in 1957, but it was more than offset by an increase in new medium-term transactions which during 1957 were twice as high as in 1956 at £156·6 million.

The commercial department of E.C.G.D., which accounts for 90 per cent. of the Department's business, normally produces a modest profit, testifying to the actuarial soundness of its operations. The sharpest criticisms levelled against it have revolved around the fact that it functions under Whitehall control, although this criticism has largely died down in recent years. The anomaly remains, however, that the Department, while it has primarily commercial aims, is run by civil servants and is therefore subject through the medium of the President of the Board of Trade to political control. This is the main anomaly which the Speed Committee is at present investigating. Whatever form of reorganisation of the Department is suggested by the Speed Committee it is to be hoped that it will not detract in any way from the good work already done by the E.C.G.D. To judge by the part it has played in recent years in stimulating British exports the E.C.G.D. has done an excellent job. Early in 1957 further minor criticisms were counteracted by improvements in the services offered by the Department, which took the form of guaranteeing against more kinds of risks, covering a greater percentage of losses and granting earlier settlement of claims.

10 *Per Cent. for Nothing?*

One of the favourable economic developments of 1957 was the trend in the terms of trade. These are measured as the ratio of import to export prices. Last year they moved something like 10 per cent. in favour of this country. This is no mean gain. It is equivalent to a trade advantage of £400 million a year or an increase of about 6 per cent. in industrial production. If ever it is possible to say that this country gets something for nothing this is such an occasion—at least at first sight.

At second sight the position is not nearly so simple. Last year the prices of imports fell significantly while those of exports went up slightly. If the fall goes on it is bound to reduce the purchasing power of those countries from which the imports came and it is then only a question of time before United Kingdom exports begin to feel the consequences of the drop in imports. Furthermore, just as there is a time lag between the drop in imports and the fall in exports, so when the trend is reversed there will almost certainly be a delay between the rise in import prices and the rise in exports. It is

possible for there to be a combination of rises and falls between import and export prices which is favourable over a long period to this country but it would be advisable to think of such an outcome as an arithmetical exercise rather than a forecast of what is likely to happen. This country will be exceedingly fortunate if it does not pay some sort of a price in terms of reduced exports for the large windfall in import prices in 1957.

Productivity Agency Proposes

The European Productivity Agency is one of the most practical in attitude of all European international organisations. It is not difficult to see the reason for this. E.P.A. addresses itself not to the politicians but to the scientists, engineers, economists, sociologists and others whose work takes them into the very broad field of productivity. The organisation's leaflet on its activities for the coming year covers courses and research projects on management, trade unions, technology, agriculture and distribution. One of the most important conferences will be the Fifth International Conference on Management Education and Training at Baden-Baden from April 9 to 15. An E.P.A. mission is visiting the United Kingdom in May to study the role of atomic science in the production, marketing and distribution of agricultural products. The mission will spend some time at Harwell at one of the basic training courses on the general use of isotopes.

A European research programme on the application of the human sciences to industry is being established in collaboration with the national productivity agencies. Another very useful task that the Agency has taken on is the preparation of a register of research and a directory of institutes. The activities arranged for trade unionists form a very important part of the programme.

Suez and Supplies

The cutting of the Suez Canal and of the Iraq Petroleum Company's pipeline in November, 1956, deprived Europe of two-thirds of its oil supplies. To maintain supplies simply by re-routing tankers via the Cape would have needed an 80 per cent. increase in the tanker capacity serving Europe. The Western Hemisphere, the only alternative source of supply, could provide less than half the 7 million tons of oil required. To meet this emergency the O.E.E.C. Petroleum Industry Emergency Group (O.P.E.G.) was set up. Royal Dutch Shell, British Petroleum and the Compagnie Francaise des Pétroles assigned experts to O.P.E.G. which set about the job of allocating available supplies on a fair and equitable basis. In this task it achieved a considerable degree of success.

The implications and lessons of the crisis are examined in *Europe's Need for Oil*, a report issued by the Oil Committee of O.E.E.C. The report states that the effects on the general economy of Europe were less serious than had been expected, and that the only long-term effect will be the general repercussions on the balance of payments position. This was partly due to the slowing down in the upward trend of industrial expansion which had already begun before the crisis.

Looking forward, it is clear that the link between the prosperity of Europe and that of the Middle East oil-producing and transit countries is as essential as ever. To avoid exposing Western Europe to further risk the Oil Committee makes a number of recommendations. Larger reserves of oil must be held in Europe. The further development of flexibility in the means of transport by alternative routes is needed. The securing of a fuller economic expansion of supplies outside the Middle East and continuous consultation and planning by governments and industry to place Europe in a better position to overcome a temporary drop in oil supplies. It is also suggested that the structure at least of the national committees should be retained.

None of these recommendations is without its difficulties. The installation of storage tanks would involve considerable capital outlay. So would the building of super-tankers and the adaptation of unloading facilities for them. Again, is the maintenance of a permanent committee system likely to solve future crises any faster than the *ad hoc* arrangement described in the report? Nevertheless, there will be general agreement with the Committee's conclusion that the successful surmounting of a major threat to the economy of Europe in the winter of 1956/57 should not be allowed to lull member countries into a sense of false security.

Information Workers Unite

The formation of a new Institute of Information Scientists heralds the day when every self-respecting firm will have its own information officer to take care of the exacting work of obtaining information quickly. Since this journal established the Engineering Information Service in 1956, experience has shown that it is the large groups, already having an information department, who make most use of outside information services. But there is no doubt that many small and medium firms are discovering for themselves that they, too, can apply knowledge and experience which have been paid for by others.

The founders of the new Institute state the aim to be "to promote and maintain high standards in scientific and technical information work and to establish qualifications for those engaged in the profession." This was the gist of a motion which was put to what the B.B.C. would call a "specially invited audience" at a meeting held in London on January 23; the motion was carried almost unanimously. About 125 people attended and listened to an outline of the plan which was put forward by Mr. J. Farradane and seconded by Mr. C. W. Hanson, both of whom are well known in the information world. Dr. G. Malcolm Dyson, a consultant in documentation, was in the chair. At the end of the meeting a temporary committee was set up to draft a constitution and do other preliminary work. Some of the things likely to be approved: subscription of about two guineas for members and one guinea for associate members; no examination for early entrants, and arrangements to ensure that the profession never becomes a closed shop; librarians not admitted to membership unless they are librarians-turned-information-officers; and collaboration with existing bodies of similar interests, especially Aslib. The membership qualification is expected to become accepted by industry within five or ten years. Mr. Farradane's address is Torran, Crofton-road, Orpington, Kent. A letter from him in ENGINEERING for June 7 last gave the first news of the plans.

The formation of this Institute is not a day too soon. There is to be an International Conference on Scientific Information at Washington in November—the one and only previous conference was organised by the Royal Society in 1948.

Insured for Everything

The post-war rise of insurance has staggered even the insurers. Yet the need for more and wider coverage remains. The question used by the *Chamber of Commerce Journal* as the title of an article—"Are You Properly Insured?"—could be satisfactorily answered in very few of this country's boardrooms. The viewpoint was that of the trader, but most firms are traders, at one stage or another in the long chain from raw materials to finished product. First there is a warning, that the type of insurance agent who handles business insurances "is not usually anything more than a plodder; from the commission aspect it is chicken-feed and does not attract the bright boys."

Perhaps the fire policy does not cover damage by lightning, or by explosion of domestic boilers or gas. Property insurance taken out by a landlord does not obviate the need to insure fixture fittings or other trade contents. Burglaries and consequential damage can be a tricky subject when a policy is due for renewal, especially when expensive claims have been made. Specification by the insurance companies as to the location of certain goods, or the provision of alarms and safeguards can invalidate the most confident claims. But what of damage by aircraft, by explosions, riots, earthquakes, storm and tempest, burst pipes, impact, accidental damage to underground pipes? One's insurance can cover books and records only to the amount of their value as stationery, when their value to the business may be immense. Drawings, patterns, specifications and even tenders (they may be worth thousands of pounds) come into this category. Too many neglect to insure against loss of profit in case of fire or other damage, or fail to insure plant and stocks at their replacement value. Loss of custom and goodwill, expenses pending, repairs, cash and many other items often escape attention.

The message is clear: never sign a policy until you understand what each clause means to your business. To do so is to take the shortest road to a bankruptcy court, at least for many thousands of small manufacturing businesses. Another message can be read between the lines: employ a first-rate insurance broker.

Letters to the Editor

PERKINS ENGINES

SIR, Thank you for including the complimentary paragraph entitled "British Engines in Demand," on page 46 of your issue of January 10, about the demand for Perkins engines. I think you may be interested to learn that there are actually more than 50 manufacturers who offer Perkins engines as standard equipment, both at home and overseas, for combine harvesters and tractors. In Argentina alone, 18 combine manufacturers fit Peterborough-made Diesel engines as original equipment.

Yours faithfully,
F. G. HOOPER,
Press Relations Officer.

F. Perkins Limited,
Peterborough.
January 21, 1958.

COOLING TOWER PACKINGS

SIR, I note from Mr. Derek J. Tow's letter, published on page 99 of your issue of January 24, that he still disagrees with a number of my observations. In view of the fact that I, in turn, disagree with most of his, and as the correspondence has already become somewhat protracted, may I offer the following suggestion? Namely, that when an engineer decides that a cooling tower is necessary to his requirements, he contacts one of the several cooling tower specialists in this country, who can then put forward alternative offers for:

(*a*) natural draught towers with either splash or film type packings, or

(*b*) mechanical draught towers with either splash or film type packings.

From the various alternatives offered, he would then be in a position to select a type of tower fitted with the form of packing most economically suited to his needs.

Yours faithfully,
E. A. HOWE,
Managing Director.

Film Cooling Towers (1925) Limited,
January 22, 1958.

Obituary

SIR ALEXANDER GIBB

If ever a man were born to be an engineer that man was Alexander Gibb. He was the fifth civil engineer in line from father to son with a family tradition which began with his great-great-grandfather, William Gibb, born in 1736. More than 100 years of family engineering tradition existed before he was born; William Gibb, his great-grandfather John, his grandfather Alexander and his father Easton, each had been a civil engineer of considerable distinction—and married daughters of engineers. John (1776-1850) had been a close associate of Telford and a founder of the Institution of Civil Engineers; his grandfather (1806-1867) was apprenticed to Telford. From the 1750's to the 1880's was the great period of civil engineering in the United Kingdom—canals, railways and artificial harbours—and the Gibb family played no little part in their construction. It was hardly surprising for a son of such a family to inherit ability as an engineer. When to an inate ability there was added environment, a family business already established and the opportunity for rigorous training, then success must almost certainly have been assured.

Alexander Gibb was born on February 12, 1872, at Broughty Ferry, Angus. He died on Tuesday, January 21, at his home in Hartley Wintney, Hampshire, perhaps the most successful civil engineer of recent years. He had guided the fortunes of the family contracting business, got caught up in the First World War (as chief engineer for ports construction, British Army in

France), become a civil servant (first at the Admiralty, then at the Ministry of Transport), and then founded the firm which bears his own name, Sir Alexander Gibb and Partners. Though among the youngest of the great consulting firms, it must easily be the largest of its kind. Honoured by several universities and by many engineering societies and institutions, he held one distinction that comes to few engineers: his biography was published during his lifetime.

His career began in 1890 when, after schooling at Rugby and one year at University College, London, he was apprenticed to Sir John Wolfe Barry, P.P.Inst.C.E., for a fee of 500 guineas to cover a training period of five years. At the end of the five years he was paid £50 for " having earned it." Much of his work at that time was on railway extensions, particularly in Scotland, but also on the Barry Docks, South Wales. It was while he was serving Wolfe Barry that he met Rustat Blake and Leopold Savile, who were to be his partners when he established his own concern. Incidentally, a colleague of those early days has left the following comment on Gibb: " his knowledge of mathematics and science was slender, but he had the gift of making the most of such knowledge as he possessed, an unerring instinct for its practical application to engineering."

The list of works on which he was engaged before the first war is long and includes such items as resident engineer for the Metropolitan Railway, London; then, later, as managing director of Easton Gibb and Son, he was engaged on such contracts as those for the King Edward VII Bridge at Kew, and the Alexandra Docks and a deep-lock entrance at Newport, Monmouthshire. In 1909, the company gained the contract for the main works which created the naval establishment at Rosyth. By August, 1914, upon the outbreak of the war, the docks were only two-thirds complete so that no part was available for H.M. ships, and Gibb is credited with pressing on with the work so that Rosyth " became of immense use to the Fleet during the vital period of the war." The total expenditure was put at the then staggering total of £6,920,000.

In 1914 he joined the Royal Engineers with whom he served throughout the war in France and Belgium, finally supervising reconstruction work at Ostend and Zeebrugge. In 1918 he was made C.B. and K.B.E., and was appointed Civil Engineer-in-Chief at the Admiralty. Only a year later he transferred to the Ministry of Transport as Director-General of Civil Engineering, and he was made a G.B.E. in 1920.

Then, in 1921, just before he was 50, he began the work for which he will be best remembered: he founded Sir Alexander Gibb and Partners, though it was not until May of the following year that the firm first occupied Queen Anne's Lodge, Westminster. Since then the firm has pronounced upon numerous projects. Professional advice has been sought from Queen Anne's Lodge by governments and large concerns from all over the world. Among the works on which Gibb gave his views were the Channel Tunnel, the Severn Barrage Scheme, and the High Dam at Aswan. The great works to which the firm has contributed are legion: docks at Singapore and Sydney, hydro-electric stations in the North of Scotland and in Africa, thermal stations at home and abroad, and communication systems—roads and railways—all over the place; everything, in fact, except a big new bridge, though they did supervise the repairs to the Menai Straits Bridge. During the second war, the firm had a hand in the Mulberry harbours, ordnance and chemical factories, and the underground factory for aeroplane engines built in the old Bath stone quarries at Corsham in Wiltshire. They prepared the designs for the air-conditioned stores in the Welsh mountain caverns where the priceless works of art from the British Museum and Victoria and Albert were taken. These undertakings have been subjects for detailed papers to the Institution of Civil Engineers. The firm's interest in hydro-electric engineering is mentioned in a book review in this issue.

Of his abilities and attainments there can be little doubt: he possessed the faculty of reaching a correct decision intuitively; he could choose the right men to assist him—and he backed them fully. He was an active member of many bodies and at one time, in the thirties, he was chairman or president of no fewer than six engineering institutions simultaneously. He certainly would not have supported the proposal that all the institutions should be amalgamated, though at the time he was President of the Institution of Civil Engineers (1936-37) he proposed a form of co-ordination emanating from that Institution.

With such a full life, it is not surprising that he suffered a number of serious bouts of illness. But it is not widely known that he had lost an eye following a fall in 1932. He was a Scot—an ardent Scot who had been President of the Burns Federation—and he had a Scottish humour. It is reported that, when his artificial eye was made, he specified " a twinkle in it."

His eldest son, Alistair, was killed in a polo accident in 1955. Of the two sons surviving him, the youngest, Michael, is a partner in the firm.

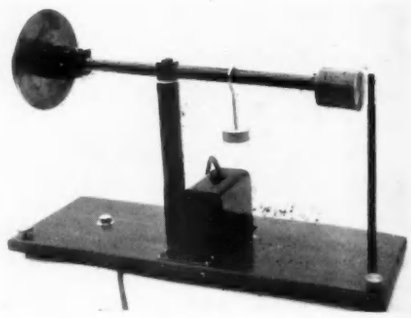
Plant and Equipment

INSTRUCTIONAL GYROSCOPE

Low Pivot-Friction Allows Long Precession

To the average engineering student gyroscopic phenomena are among the more mysterious implications of Newton's laws of motion; the mathematical treatment is a little involved and the physical reason for the observed behaviour is not immediately apparent. In teaching such a subject a practical demonstration is of much value.

The gyroscope shown in the illustration was



The instructional gyroscope demonstrates the principles of gyroscopic behaviour. With it the qualitative laws of gyroscopic action may be verified.

designed by Mr. E. Toner, lecturer in mechanical engineering at Reading Technical College, and is manufactured by Plint and Partners Limited, Wargrave, Berkshire. With its aid the principles of gyroscopic behaviour may be demonstrated and the quantitative law of gyroscopic action may be verified.

The gyroscope consists of a steel disc driven at about 5,000 r.p.m. by an electric motor and carried at one end of a balanced steel beam, which is supported on a hardened steel cup and cone bearing. The 18-volt motor is supplied by a mains transformer and current is conducted to the beam through a mercury slip ring. With this arrangement pivot friction is very low and precession persists indefinitely.

With the gyroscope running the direction of the beam remains stable. If, however, the balance of the beam is disturbed by a couple in the vertical plane—produced by the addition of jockey weights—the gyroscope will start to precess in the horizontal plane and in doing so will exert a precessional couple equal to that set up by the jockey weights. If the weights are moved from one side of the point of balance to the other the direction of precession is reversed.

The basic law of gyroscopic action is of the form

$$C = \frac{I}{g}\,\omega_1\,\omega_2$$

where

I = polar moment of inertia of disc;
C = applied couple;
ω_1 = angular velocity of disc about own axis; and
ω_2 = angular velocity of precession about pivot.

To verify the law with the instructional gyroscope, a series of couples is applied by means of the jockey weights. The rate of precession is observed directly by means of a stop-watch and the speed of the gyroscope disc is determined by observation with a stroboscope. It is also a relatively simple matter to explain to the students the source of the gyroscopic couple.

HIGH PERFORMANCE PUMP

General Purpose Lightweight Unit

High capacity, high operating pressures, and small size are the outstanding features of the British-designed pump now being made by Holman Brothers, Limited, and Goodyear Pumps, Limited, both of Camborne, Cornwall. As an example, the middle of the three sizes in production will pump 30 gallons per minute against a head of 300 ft. for a weight of 11 lb. (when made in aluminium). The same body in iron weighs only 7 lb. more. An example is shown in Fig. 1 and a section in Fig. 2.

The pump is intended for general use and will handle any fluid from molasses to ether. Tests have shown that it can pump soft fruit, such as strawberries in syrup, without crushing the fruit. It can also run on " snore " indefinitely.

The rotor takes the form of an Archimedean screw, but the unique feature of the pump is that this screw engages with a wheel, giving the whole the appearance of a worm and wheel gear. This wheel forms the pressure seal of the pump and is coated with an elastomer which can be chosen to suit any particular liquid. The face of the pump barrel is also coated. A groove is cut in the periphery of the rotor screw to improve the sealing and lubrication. Since the rotor is short, its shaft can be made very rigid, which means that high speeds can be used without any danger of whirling. For normal operation the pump runs at 1,500 or 3,000 r.p.m. but trials have been successfully carried out at 6,000 r.p.m. when of course the output is virtually doubled. The pump is self-priming.

Mechanical seals are used and are duplicated at each end. From the rotor outwards they consist of a lip seal and a face seal followed by a drain space and then a face seal and a lip seal protecting the bearing. Thus, should there be any leakage from the pump chamber it will drain away before it can damage the bearings. During extended trials at the makers' works the seals have given completely satisfactory service. Taper roller bearings are used.

The three sizes at present being made have suction and delivery connections of 1¼ in., 1½ in. and 2½ in. diameter respectively. Performance figures for the middle size are given in Fig. 3. It will be seen that for a delivery of 28 gallons per minute against a head of 300 ft.

Fig. 1 Small size and light weight are the features of the Goodyear pump.

the pump absorbs 4¼ h.p. when running at 3,000 r.p.m. Under these conditions the efficiency is given as just over 60 per cent. This model measures 8 in. by 4 in. by 9 in. and, as has been said before, weighs 18 lb. when made in iron. The largest size is capable of delivering 1 ton per minute at 3,000 r.p.m. and weighs 60 lb. in iron. On the suction side the pumps can work to a vacuum of 27½ in. of mercury, beyond which value cavitation tends to occur. In all models the output is directly proportional to the speed. Reversing the direction of rotation also reverses the flow of the liquid being pumped. The fact that all engaging surfaces give rubber to metal contact, and are liquid lubricated, keeps the friction losses low and the wear negligible.

One of the applications shown at a recent demonstration was in a portable unit with a single-cylinder petrol engine providing the drive. The light weight of the pump shows to advantage here. Another application was a marine version with the rotor shaft vertical; this showed the saving in floor space that could be effected.

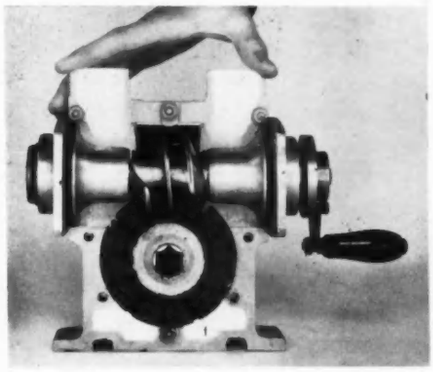


Fig. 2 The wheel meshing with the screw forms a seal which makes the pump a positive displacement type suitable for delivery pressures of 150 lb. per sq. in. and over.

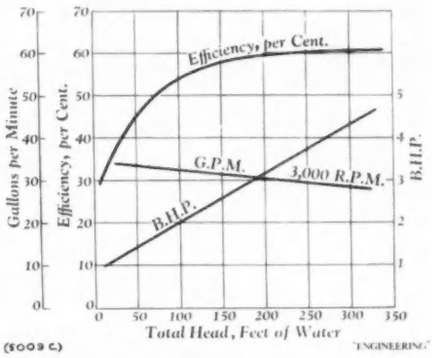
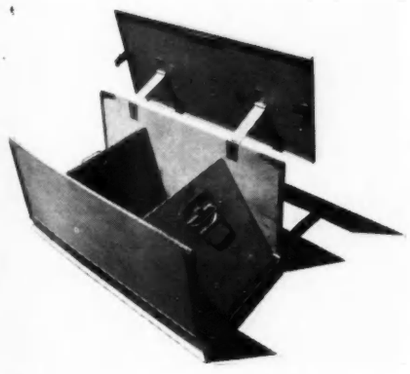


Fig. 3 Performance figures for the 1½ in. size pump, when running at 3000 r.p.m. Delivery is directly proportional to speed.

Other models were shown pumping molasses (the temperature was about freezing point) and running on snore.

COLLAPSIBLE CONTAINER

A newcomer to the ranks of collapsible containers available in this country is the Retemba, now being made and marketed by the Warwick Production Company, Limited, Birmingham-road, Warwick. Of Swedish origin (it was developed by the Bofors Company) it is made of five-ply with an extruded aluminium framework. Various sizes are in use in Sweden where they have undergone extensive trials by the railway authorities. They have been found to be able to withstand over 100 journeys without showing any need for repairs.



The Retemba collapsible container has shown itself capable of enduring extremely rough handling.

Two sizes are in standard current production, one measuring 30 in. by 15 in. by 15 in. internally and the other 30 in. by 22½ in. by 15 in. The latter has a capacity of 5·8 cub. ft. and weighs 37 lb. and the former holds 3·9 cub. ft. for a weight of 29 lb. When collapsed the volume is only 17 per cent. of that when erected and the height is approximately 3½ in. The larger size takes loads up to 400 lb. and has actually carried double this under test conditions.

The lid is hinged to one of the sides and is kept closed by spring clips. The same clips hold the container together when it is collapsed. Provision is made for a sealing wire to be inserted through the clips as an indication that the lid has not been opened during transit. The ends are kept open by springs mounted on the inside of the sides, which can be depressed by the fingers when it is desired to collapse the container. The ends then fold in and the sides rest on top of them, the whole being covered by the lid. The formation of the extrusion round the base is such that positive stacking can be achieved in either the open or collapsed conditions. One great advantage is that there are no loose parts to be damaged or lost.

As mentioned earlier the panels are made of resin-proofed 10 mm. plywood and are mounted in a frame of hard drawn aluminium extrusions. The strength of a container was clearly shown when a demonstrator repeatedly jumped on its lid. Although only two standard sizes are quoted, the Retemba can be made in any size to order, the largest yet supplied having measured 6 ft. by 8 ft. by 4 ft.

TELEPHONE TESTER

In the past, trunk operators have often had to rely on their own judgment in deciding when to report a circuit unserviceable. This led to non-conformity to standards and caused misdirection of maintenance staff. A new portable serviceability tester has recently been introduced by Automatic Telephone and Electric Company Limited, 8 Arundel-street, London, W.C.2.

The company say that the new tester allows non-technical staff make a series of straightforward tests to find out whether carrier-derived or physical circuits are fit to carry traffic. The five standard tests it is designed for are:

(1) Measurement at 800 c/s of the attenuation of a physical circuit with loss up to 10 db.

(2) Measurement at 800 c/s of loss up to 40 db. and gain up to 10 db. of carrier-derived circuits.

(3) Measurement of psophometric noise down to −60 db.

(4) Check of synchronisation of local and distant carrier oscillators.

(5) Check of operation of voice-frequency ringing equipment at normal and low levels.

★ ★ ★

ZETA OPENS UP

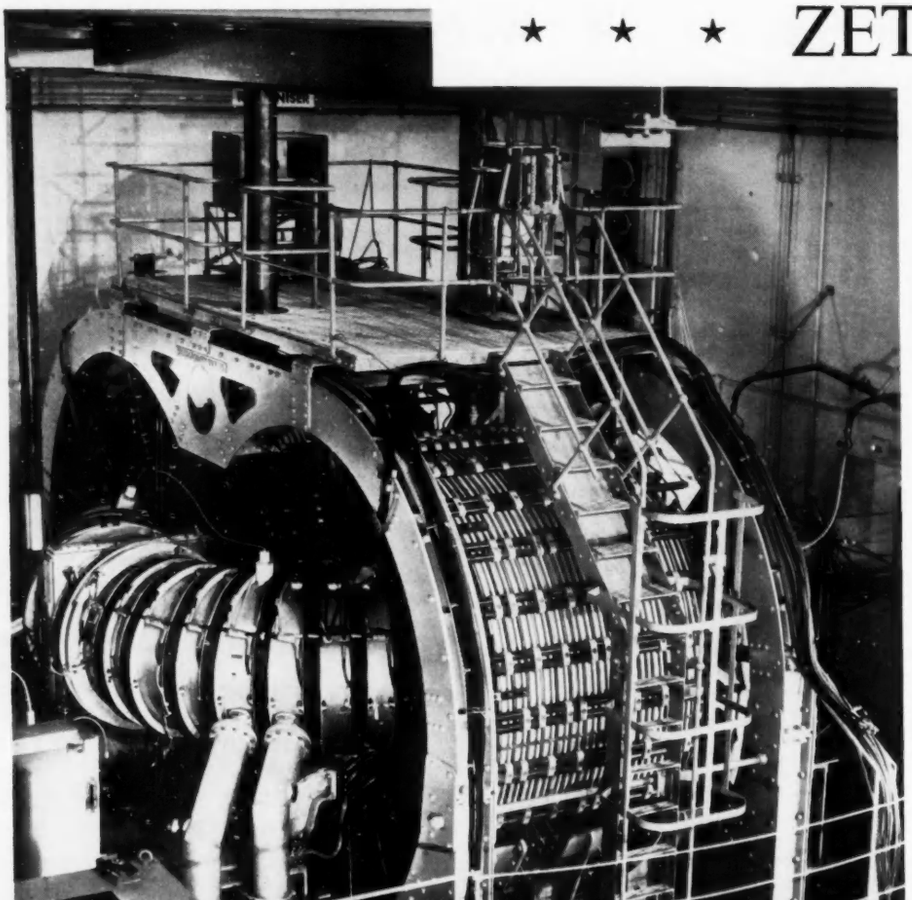


Fig. 1 Zeta, showing pulse transformer and part of the torus which carries the gas discharge.

WHAT THE ZETA EXPERIMENTS MEAN

By R. S. Pease, M.A.

Group Leader,
Gas Discharge Group,
A.E.R.E., Harwell.

WHEN Zeta first went into operation on August 12, 1957, no one knew whether it would lead to any substantial progress towards the goal of thermonuclear power. The machine itself was designed on the basis of experience in smaller toroidal discharges, and on the basis of three general principles: (1) that if a large enough current is passed through a small enough quantity of gas, the gas will be heated to the temperatures required; (2) that the discharge impedance goes down as the tube bore is increased; and (3) that an external magnetic field not only reduces the impedance of the discharge, but also is likely to yield some measure of stability.

No detailed theoretical predictions existed, because of the complexity of plasma physics and because of the wide variety of the possible modes of operation of gas discharges. For instance, some people suggested that we would merely generate a series of power arcs between the aluminium liners; others suggested that we might generate a beam of high velocity electrons; the performance of the smaller toruses suggested that we should achieve a discharge, but an unstable one. One theoretician, regarded by most of us as wildly optimistic, suggested that we might achieve a stable discharge.

Our experiments have shown that in some ways all these modes of operation can occur in Zeta. The important result is that we can achieve a stable discharge isolated from the torus walls by suitable choice of external magnetic field. We have found that the stable plasma reaches the high temperatures, of the order of 5 million deg. K., necessary for producing thermonuclear reactions, and that nuclear reactions do indeed take place in the apparatus. Whether these nuclear reactions arise from a strictly random motion of the deuterons (that is, a thermonuclear process) or whether they are due to an ordered form of motion of some of the deuterons (that is, non-thermonuclear) remains to be settled experimentally; present evidence favours a thermonuclear process under most conditions of operation. However, this problem is not of overriding importance, since our results on stability and temperature suggest that there is no insuperable difficulty in using Zeta-like machines to obtain plasmas which are both hotter and also contained for longer times. In this connection, the confirmation of our results by the A.E.I. research team and by the Los Alamos group are very encouraging.

We are at present planning modifications to the existing Zeta to extend both the magnitude and the duration of the current pulse, and simultaneously plans are being discussed for a machine which will generate an amount of nuclear energy comparable to that radiated by the gas. Although there are undoubtedly many problems to be resolved, these at present seem to me less formidable than the problem of plasma stability which has been solved by Zeta.

WATER has always been vital to living things upon this planet; even their origin has been ascribed to it. But it has never been foreseen that by means of water civilised life on earth might be prolonged. According to figures quoted by the United Kingdom Atomic Energy Authority, the estimated reserves of existing fuels, including uranium and thorium, will last at present rates of consumption no more than 500 years. Whereas the deuterium or heavy-hydrogen content of seawater is calculated to be sufficient to sustain present energy consumption for a thousand million years. By that time whatever thinking creatures inhabit the earth will doubtless be capable of using the much more abundant common isotope of hydrogen as fuel.

The forces that hold together the protons and neutrons of any given atomic nucleus are associated with a corresponding quantity of energy. In terms of this binding energy, the elements of intermediate weight may be regarded as more stable than the heavy elements (such as uranium) and the light elements (like hydrogen). Thus certain heavy elements can be split to form intermediate elements, at the same time yielding energy; while nuclei of hydrogen isotopes can be fused to form helium, say, also liberating energy. In fusion, however, the energy evolved per unit mass is significantly greater.

The importance of the successful experiments with the Zero-Energy Thermonuclear Assembly at Harwell is thus apparent. ZETA is an early step in controlling thermonuclear reactions, by means of which energy may be obtained from the fusion of light nuclei, including those of deuterium. Unlike fission reactors, Zeta is almost entirely within the province of the electrical engineer. It is essentially a transformer in which the closed secondary circuit is an ionised gas heated by the current and compressed into a narrow toroidal filament by the current's field. The containing vessel or torus is thus protected from contact with the high-temperature gas. The gas is mainly deuterium and the heating effect is believed to be sufficient to promote thermonuclear reactions.

If two nuclei are to approach each other closely enough for fusion to occur, means must be provided to overcome the mutual repulsion due to their like electrostatic charges. Clearly, if the nuclei are moving towards each other at high speed their momentum will tend to overcome this resistance, with battering-ram effect. One method of achieving high speeds is to heat a gas (to temperatures of the order of 10^8 deg. C.) so that in accordance with kinetic theory the random motion of the nuclei is sufficiently agitated to produce violent collisions. Reactions caused in this way are called thermonuclear.

The problem of converting the energy evolved into electric power may also be the exclusive concern of the electrical engineer. Direct conversion may be possible, using conventional electromagnetic principles, since the conducting gas continuously undergoes cyclic expansion and contraction.

NEW PATHS IN POWER ENGINEERING

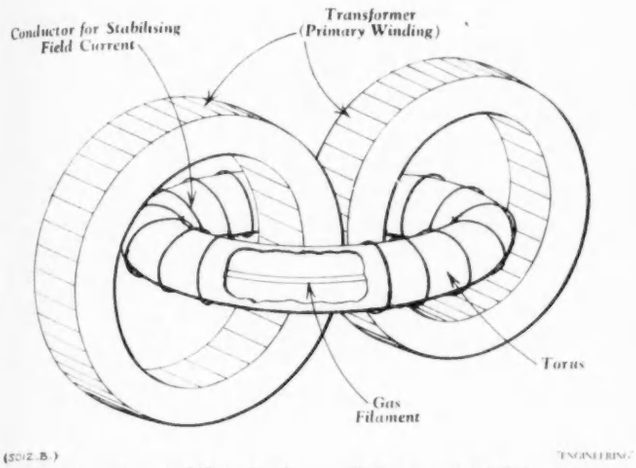


Fig. 2 Arrangement of Zeta showing gas discharge and stabilising-field coils.

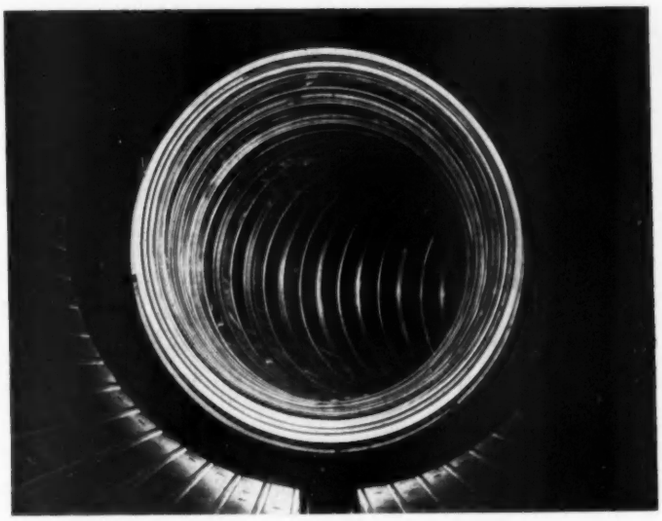


Fig. 3 Interior of the torus before assembly with the pulse transformer.

FIRST STEPS IN CONTROLLING THERMONUCLEAR REACTIONS

ON August 12, 1957, a large experimental apparatus for studying the controlled release of energy from thermonuclear reactions was started up at the Atomic Energy Research Establishment, Harwell. On August 30 this apparatus, which is known as Zeta, and is illustrated in Fig. 1, was first operated under conditions that produced nuclear reactions; neutrons emitted in these reactions were observed when deuterium gas was heated electrically by means of an iron-cored transformer to temperatures in the region from 2 to 5 million deg. C. The hot gas was isolated from the walls for periods of 2 to 5 thousandths of a second. The heating process was repeated every 10 seconds. The high temperatures achieved, together with the relatively long duration for which the hot gas has been isolated from the tube walls, are the most important experimental results obtained so far. While much longer times (perhaps several seconds) are required for a useful power output there appears to be no fundamental reason why these longer times, together with much higher temperatutes, cannot be achieved.

The source of the observed neutrons has not yet been definitely established. There are good reasons to think that they come from thermonuclear reactions, but they could also come from other reactions such as collision of deuterons with the walls of the vessel, or from bombardment of stationary ions by deuterons accelerated by internal electric fields produced in some forms of unstable discharge. In Zeta the number of neutrons produced by each pulse of energy as the current was doubled was roughly that which might be expected from a thermonuclear reaction at the measured temperatures. These temperatures, the highest being in the region of 5 million deg. C., have been definitely established.

Heating and Containment

As the Atomic Energy Authority have stated in their last two annual reports, research has been in progress for some years to investigate the possibility of producing energy in a controlled manner from thermonuclear reactions. Over two years ago design began of a large installation for this work and in August, 1957, Zeta started up, with the results described above. The reaction being studied in Zeta is that in which deuterons (nuclei of the heavy hydrogen isotope deuterium) collide with one another and fuse to form heavier nuclei, releasing energy and some neutrons in the process. For fusion to be possible the deuterons must have enough energy to overcome the initial electrical forces of repulsion between them; this necessitates heating the deuterium gas to temperatures of millions of deg. C. The hot gas must be kept away from the walls of the container otherwise it falls in temperature, and vaporisation of the wall materials causes contamination of the gas.

The principle adopted in Zeta, the arrangement of which may be gathered from Fig. 2, is to pass a large electric current through the deuterium gas, which is contained in the torus illustrated in Fig. 3. This current sets up an electric discharge in the gas (analogous to the discharge in a neon tube) which heats it and also produces an intense magnetic field around the column of hot gas. The lines of force may be regarded as bands tightening about the gaseous plasma, as indicated in Fig. 4. This magnetic field causes the discharge to become constricted (pinch effect) and hence heated still more. Since it also causes the discharge to wriggle about, this field is by itself not enough to keep the discharge away from the walls. The instability has been suppressed by applying an addi-

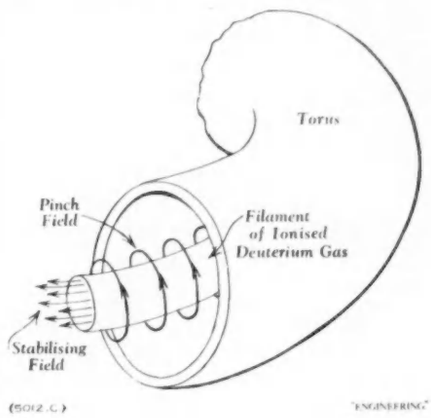


Fig. 4 Plasma containing and stabilising fields.

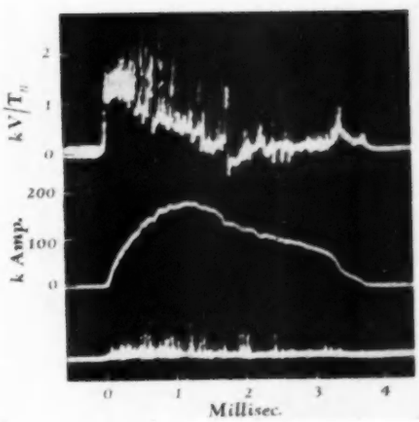


Fig. 5 Oscillograph recordings with Zeta.

The traces represent: top, the voltage per turn of the transformer; middle, the secondary current; and bottom, the pulses produced by proton recoil in a scintillation neutron counter. Conditions: gas, deuterium with 5 per cent. nitrogen and 10 per cent. oxygen; pressure, 0·13 × 10^{-3} mm. mercury; axial field, 160 gauss.

Reading Guide

The article at the foot of columns one and two on page 134 discusses the significance of the Zeta results and has been written for ENGINEERING by a group leader in the Harwell thermonuclear team; while column three contains a brief introduction. On this and the following page is a description of Zeta and the experimental methods employed. Full details of this research and of corresponding work in America were published in *Nature* on January 25. An article by Dr. A. A. Ware of the A.E.I. Research Laboratory, Aldermaston, entitled "Controlled Thermonuclear Reactions" and published in ENGINEERING on November 15 (page 610), provided a comprehensive background to the subject. The problem of identifying thermonuclear reactions was examined in Atomic Review last week, which also included a list of references to previous articles on fusion in ENGINEERING and a report on cold fusion. A glossary of terms appears on page 142 of this issue. Research on thermonuclear reactions at the Atomic Weapons Research Establishment, Aldermaston, were discussed in a paper by Dr. H. A. B. Bodin and Dr. J. A. Reynolds, published in ENGINEERING last October 25 (page 538), and a paper by Academician I. V. Kurchatov describing Soviet work on pulsed gas discharges was published in ENGINEERING, vol. 181, page 322 (1956). An account of fusion work at the A.E.I. Research Laboratory and in America will be published in a subsequent issue. Leaders of the research team and companies concerned in the construction of Zeta are named on page 142.

Continuing ZETA

tional steady magnetic field parallel to the axis of the tube and in the direction of the discharge current as indicated in Fig. 4; a further correction is provided by eddy currents induced in the surrounding metal walls when the current path (or channel) changes its position.

Zeta: Design and Operation

Zeta comprises a ring-shaped aluminium tube or torus of 1 metre bore and 3 metres mean diameter, which contains a gas at low pressure—about 10^{-4} mm. of mercury. The gas is made weakly conducting by a radio-frequency discharge. The toroidal ionised gas plasma forms the secondary of a large iron-cored pulse transformer. A condenser bank, storing up to a maximum of 5×10^5 joules, is discharged into the primary of the transformer, and induces a unidirectional current pulse in the gas forming the short-circuited secondary. The current pulse in the gas lasts for about 4 milliseconds and is repeated every 10 sec.; peak currents up to 200,000 amperes have been obtained and pulses up to 5 milliseconds duration. The axial stabilising field, variable from 0 to 400 gauss but usually about 200 gauss, is generated by current-carrying coils wound on the torus. At the high temperatures obtained, appreciable leakage of the axial flux does not appear to be possible.

Typical current and voltage oscillograms are shown in Fig. 5. The top trace is the voltage

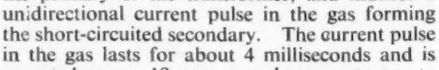


Fig. 7 Streak picture of a helium discharge.

Conditions: initial gas pressure, $0{\cdot}25 \times 10^{-3}$ mm. of mercury; axial field, 160 gauss; peak current 130 kA. The tube walls lie at the upper and lower boundaries of the dark region.

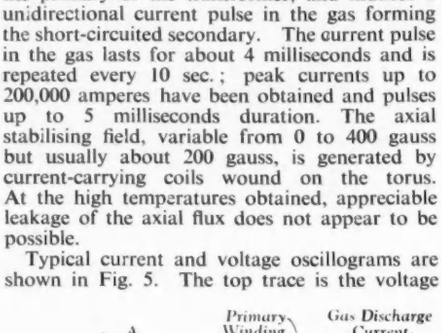


Fig. 6 Basic electrical circuit, showing switching.

per turn measured by a loop round the iron core enclosed by the discharge tube. The length of the discharge path is roughly 1,000 cm., so the initial electric field at the boundary of the ionised gas is about 2 volts per cm. The main circuit is substantially that shown in Fig. 6, and the primary winding is short circuited (by closing switch A and opening B) when the voltage per turn is zero, thus preventing the charge on the condensers from reversing. The second trace shows the current flowing in the gas, which persists for about 2 milliseconds after the primary is short circuited. With the fall in current the plasma expands until it reaches the walls, whereupon it cools. A sudden increase in resistance accompanies this process, producing a severe voltage transient, perhaps tens of kilovolts. Destructive transients of this kind are suppressed by the addition of 5 per cent. nitrogen without affecting the neutron yield.

Corroborating Evidence

In Zeta, emission of neutrons has been observed throughout the current pulse, and during each pulse up to 3 million neutrons are emitted. But as has been suggested, neutrons may be produced by several mechanisms in addition to thermonuclear reactions. A thermonuclear yield cannot therefore be proved by a large number of corroborating neutron measurements, but must in addition be in agreement with the basic understanding of the processes involved and with measurements of the plasma physics. In the case of Zeta, therefore, a large number of different measuring devices are used. These include magnetic probes, comprising small coils to measure current distribution; double probes to determine electron temperature; microwave-beam devices for measuring electron density and temperature (the effect employed is similar to the manner in which the Heaviside and Appleton ionised layers of the atmosphere transmit some wavelengths and reflect others); neutron counters to detec nuclear reactions, including those of thermonuclear character; scintillation counters to measure X-ray output; and image converter cameras for taking high speed photographs, through observation slits fitted in the torus (a strip of film is passed across the aperture at a given rate, so that the photograph will show changes in the discharge with time). A streak photograph of a heavy hydrogen discharge is shown in Fig. 7.

Possibly the most important evidence in confirming the occurrence of thermonuclear reactions is provided by temperature measurements. These are obtained spectroscopically. The temperature of gas discharges may be determined by measuring the light emitted by the gas atoms, but the procedure is complicated in this case because, at the temperature of the discharge, the hot deuterium atoms are completely stripped of their electrons and therefore do not emit a line spectrum. One method of solving this problem is to mix with the deuterium a small quantity of some heavier gas, such as oxygen or nitrogen, the atoms of which are not stripped of all their electrons under these conditions, and to study the spectral lines emitted by this impurity; the random motion of the high-energy impurity atoms which make many collisions with the deuterium atoms and so reach the same energy causes the spectral lines to broaden, owing to the Doppler effect, and the amount of broadening is a measure of the ion energy. In other words, the apparent colour of an ion depends whether it is moving towards or away from the spectrometer, so that with random motion many colours will be presented. Many measurements by this method have indicated temperatures in the region of 2 to 5 million deg. C. (Although electrons, which carry a negative charge, are stripped from the nuclei in an ionised gas, they should nevertheless be retained in the plasma to minimise the overall repulsion effect of the positive nuclei.)

What the Results Show

The high temperatures achieved in Zeta, and the relatively long duration for which the hot gas has been isolated from the tube walls are the most important experimental results to date. Zeta is larger than other similar apparatus so far used in the West, and it seems reasonable to suppose that containment can be longer sustained in a larger torus, particularly one with conducting walls. In Zeta containment lasted a few thousandths of a second as against a few millionths in other apparatus. Nevertheless, smaller equipment, both torus and straight tube, is yielding valuable information on the effect of size on performance. Temperatures have been measured spectroscopically only in Zeta and the A.E.I. Sceptre III; and it is, therefore, fair to say that only in Britain has there been substantial confirmation that thermonuclear reactions have occurred.

The preliminary results demonstrate that it is possible to produce a stable highly ionised plasma isolated from the walls of a toroidal tube. The containment time and high electrical conductivity are both adequate for detailed study of magnetohydrodynamical processes.

Professor Lyman Spitzer, of Princeton University, commenting on the Zeta results, points out that the assembly is behaving rather better than calculations would predict. In a gas discharge, electrons are first speeded up and communicate their energy to the heavier ions, but in Zeta the ions are speeded up far more rapidly than this explanation would suggest. It would appear that an unknown mechanism is involved. Fig. 8 indicates how the ion temperatures estimated from neutron yield differ from those given spectroscopically. This effect may be important in thermonuclear reactor design.

To identify a thermonuclear process it is necessary to show that random collisions in the gas between deuterium ions are responsible for the nuclear reactions. In principle, this can be done by calculating the velocity distribution of the reacting deuterium ions from an exact determination of both the energy and direction of emission of the neutrons. The neutron flux so far obtained is insufficient to attain the desired accuracy of measurement.

The Next Steps

The experiments are to be continued with a modified Zeta, but in addition a larger installation is to be built. The first stage of the project was to study the heating of deuterium gas up to 5 million deg. C. by an electric current and containment by pinch effect. This stage culminated in Zeta which was built to establish conditions in which controlled thermonuclear

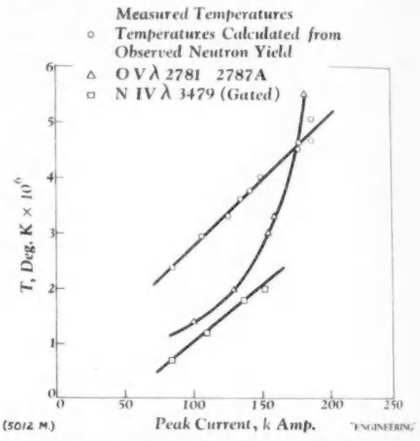


Fig. 8 Ion temperature in gas discharge as calculated from observed neutron yield and from Doppler broadening of added-gas spectra.

Conditions: initial gas pressure, $0{\cdot}13 \times 10^{-3}$ mm. deuterium and 5 per cent. nitrogen; axial field, 160 gauss.

reactions might occur. The heat output is negligible compared with the electrical input—the ratio of input to output is about 10^{12}. The neutrons produced in Zeta at 2 million deg. C. are multiplied 300 fold as temperatures of 5 million deg. C. are approached, where emission is of the order of a million. The plasma current in Zeta is to be increased by the provision of more condensers, and at 25 million deg. the number of neutrons per pulse should increase at least 10,000 times, but the input to output ratio will still be large. Although it is believed that reactions will become more numerous as temperatures rise, the heating effect of the current is expected to diminish.

To break even, temperatures of the order of 100 million deg. C. for deuterium gas and about 40 million deg. C. for a mixture of deuterium and tritium would be necessary. (Tritium is super-heavy hydrogen of atomic mass 3 obtained by neutron irradiation of lithium 6; the use of a lithium blanket in a thermonuclear reactor to absorb the liberated neutrons would provide an obvious economy.) ZETA's successor, which will be designed to achieve the break-even point, will be the vehicle for stage two. The third stage will be the construction of a practical and economic prototype possibly requiring a pulse duration of several seconds, and stage four would be commercial application.

Companies in the News

Tramps Wanted

The possibility of orders for ships being cancelled was admitted by Colonel T. Eustace Smith, chairman and managing director of Smith's Dock Company, " if the freight markets remain depressed for long, and if the cost of money remains high." So far, Smith's Dock have had no cancellations and are experiencing a period of high activity. Their order book is large and, Colonel Smith believes, " a sound one." He concedes that " there is a possibility of tankers being overbuilt " but finds the prospects for ore carriers, " with reasonable delivery," are still good.

There have been indications recently that more work is becoming available for tramp ships, particularly for the shipment of cargoes to the Far East. The prospects of a major increase in American aid shipments to that area to match the offers being made by the Soviet Union are creating confidence that recovery in freight rates may not be far off. One thing is certain, however, that—barring a new emergency on the Korean scale—there will be no return to former levels when any pre-war and war-built tramps could earn high profits. Expansion in world trade will enable modern ships to earn good rates and will therefore act as a spur to those who hesitate in placing building orders. Either modern tonnage or no more business is likely to be the rule during the next few years. There is a fantastic leeway to be made up and therefore little cause for apprehension on the part of the shipbuilding industry. As Colonel Smith pointed out, " the shipbuilding position in this country is healthy, with orders for 6·75 million tons valued at approximately £1,000 million." There are also signs that the foreign advantages in building costs and quicker deliveries are becoming less potent factors in competitive ability.

Smith's Dock are in the fortunate position of being able to find the £425,000 needed for capital improvements out of reserves. William Denny and Brothers must borrow to finance their modernisation and reorganisation scheme, admittedly one on a much larger scale (estimated to cost £1·25 million). Like Smith's Dock, William Denny are well placed to take advantage of a boom in tramp tonnage; with modern equipment their prospects of building competitively at a good profit should improve considerably.

Cutting Out Smoke

The campaign against smoke pollution is not meeting with as much support as had been hoped. At a clean air conference held in Birmingham last month it was revealed that 33 of the 54 local authorities represented on the regional clean-air council had still taken no action at the time of the latest count to establish smoke-control areas, and another 12 had given the proposal only preliminary consideration. The clerk of the Willenhall council told the conference that " people want an open coal fire as their fathers had before them and they do not want to be disturbed in the habits of a lifetime."

Speaking of the slump in the sales of gas appliances, Mr. A. F. Oatley, chairman and managing director of Cannon (Holdings) Limited, complained that this was largely due to credit restrictions and high increases in purchase tax. He quoted Mr. Nabarro's question in the House of Commons concerning the tax and hire purchase controls on clean heat appliances using indigenous fuel while solid fuel and oil burning appliances are imported and remain free of both credit control and purchase tax. He asked the Government to explain their fiscal policy and " the reasoning behind these economics of the lunatic asylum." There is no doubt that Government policy has been hard on the makers of gas appliances and, in general, not very helpful to those local authorities who have been attempting to carry out a smoke abatement policy.

Electrical appliance manufacturers, on the other hand, have received much kinder treatment and sales have been booming for several months. The ability of the Electricity Boards to grant long-term credit, up to 4 years, at low rates of interest, has done much to stimulate purchases of immersion heaters, cookers and space-heating appliances. The next few months should see a sharp revival in the interest in central heating, which should be stimulated by extensive advertising campaigns by the oil companies. If the National Coal Board take the decision—unavoidable in the long run—to raise prices of large household coal, there should be rapid and uninterrupted progress.

Hawker-Bristol Fly Ahead

While discussions continue in Whitehall on the B.E.A. jetliner order, the Hawker-Bristol partnership are going ahead to establish their design commercially. They are proceeding immediately to follow up negotiations with a number of interested customers. A sales and engineering team left for the United States last week at the invitation of a prominent American airline to discuss plans for a fleet of the projected Bristol 200. The team is a powerful one, led by Dr. A. E. Russell, chief engineer of Bristol, who has recently been appointed chief engineer of the joint company formed to develop and produce the new aircraft.

This move shows that Hawker-Bristol intend to go ahead with their project if they can get enough orders initially to warrant taking the immense financial risk involved—whatever the B.E.A. decide to do. There could be few better ways of demonstrating their part in the design. The team will visit the headquarters of a number of airlines and will present to their management detailed operating analyses showing the performance of the Bristol 200 in widely varying United States domestic routes.

The Government's insistence that British aircraft firms should come together in two or three groups in order to further the country's interests as well as their own may thus bear early fruits. A new kind of selling is being attempted, on the basis of paper designs and mathematical data backed by engineering resources and proven achievement in the specialised field concerned. Bristol initiated a sales drive in North America last year and the team which has gone deals by means of technological persuasion and performance curves. This is a most interesting development in sales techniques in respect of standard products, and will involve the use of new methods which may be widely applicable to other engineering products.

Tools and Textiles

Manufacturers of both machine tools and textile machines have been hit in recent months by declining orders. The latest statistics available indicate that machine-tool deliveries in October totalled £8·97 million, the highest ever reached. New orders continue to be much lower than a year ago and the industry's order book was down to £82·26 million, compared to £101·99 million in October, 1956. There was, however, a sharp increase in the value of orders booked in October though this was still some 7 per cent. below the level a year ago. There is, however, a strongly favourable factor which may exercise a powerful influence on exports over the next few years. With a little more time to spare now that increases in capacity have been effected, machine-tool makers are busy improving their products, and creating new ones. In his annual statement to the shareholders of Kendall and Gent Limited, their chairman, Mr. F. C. Mosley, said that they had embarked " upon an intensive programme of re-designing to further improve the technical advantages of our products " and that a number of new machines incorporating electronic controls had been added to the range. The British industry's increasing awareness of the need for a dynamic product policy is the most hopeful development of the past twelve months.

The development of new types of machine-tool controls, which was discussed by the chairman of E.M.I. Limited, Mr. J. F. Lockwood, in his annual statement last month, is proceeding rapidly. So far such controls have found their main uses in unusual conditions where precision and remote control have been required but the range of applications is being extended—in E.M.I.'s case by the introduction of new equipment, including simpler and cheaper kinds, for such things as die-sinking and drilling tables. Other manufacturers have developed control systems which permit automatic production of short runs cutting out (with the help of computers) much of the skill required in setting and operating the machines.

Apart from technical advances, there are signs that manufacturers in the engineering industry are thinking once again of placing orders for plant and machines which had been delayed at the time of the Suez crisis. It is too early to say whether or not this is a widespread movement but certainly here and there a return of confidence has led to the placing of orders.

Chippenham Signals at Green

An excellent example of the considerable strengthening which has taken place in British engineering in recent years is provided by the Westinghouse Brake and Signal Company. Their chairman, Mr. A. R. S. Nutting, told shareholders in a statement circularised with the company's accounts the good news of a successful year, with profits up by nearly 20 per cent. to £2·14 million. However, orders received by the company during 1956-57 (year ending September 28) were " greatly in excess of the previous year's record," and deliveries exceptionally large. " We met with considerable success," said Mr. Nutting, " on the basis of price, delivery dates, and technical excellence for large contracts abroad." Much of their success was due to the benefits now accruing from the large capital expenditure of the past years on modernisation and re-equipment. This applies also to many others of the more progressive engineering concerns and a good performance can be expected during the current year, even under highly competitive conditions.

In his review of the activities of the constituent companies of the group, Mr. Nutting announces several interesting developments. The Brake Division of the parent company has formed an automotive and industrial products division which enables " the demands of the commercial road vehicle industry and of the industrial and marine fields (for brakes and pneumatic control equipment) to be dealt with in a satisfactory manner." As in the case of vacuum brakes, the demand for electric railway signalling has greatly increased through the placing of large orders by British Railways under their modernisation programme. Exports are also high, accounting last year for half the total sales of signalling equipment. In the rectifier field Westinghouse were somewhat behind the world, relying mainly on selenium. Last year they introduced a germanium type and have recently made agreements with the Westinghouse Electric Corporation of the U.S.A. which the chairman said " will link together our great technical resources " in this field. Previously the only link was a sentimental one, both companies having been formed by the same man, George Westinghouse. An agreement also exists with the Radio Corporation of America in the field of transistors and rectifiers, so the company are therefore potentially in an exceptionally strong position. Mr. Nutting ended on an optimistic note—" the current year promises well "—and so it would seem do subsequent years.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Brains Trust: "Women's Place in the Electrical Industry." Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., Feb. 3, 6.30 p.m.

British Institution of Radio Engineers

LONDON
"Radio Investigations During the International Geophysical Year," by Dr. W. J. G. Beynon. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Feb. 5, 6.30 p.m.*
MANCHESTER
"Electronic Musical Instruments," by Alan Douglas. North Western Section. College of Technology, Sackville-street, Manchester 1. Thurs., Feb. 6, 6.30 p.m.

Building Centre

LONDON
Films: "Tube of All Trades," exhibited by Stewarts and Lloyds, Ltd. Wed., Feb. 5, 12.45 p.m.

Chemical Society

BELFAST
"The Pattern of Research in the Electrical Industry," by Dr. H. K. Cameron. Northern Ireland Branch. Queen's University, Belfast. Fri., Feb. 7, 7.15 p.m.
EXETER
"Why Polymerisation Occurs," by Professor F. S. Dainton. Exeter Branch. Washington Singer Laboratories, Prince of Wales-road, Exeter. Fri., Feb. 7, 5 p.m.
OXFORD
"Steric Hindrance in Inorganic and Analytical Chemistry," by Dr. H. M. N. H. Irving. Oxford Branch. Inorganic Chemistry Laboratory, Oxford. Mon., Feb. 3, 8.15 p.m.

Combustion Engineering Association

MANCHESTER
Brains Trust on "Mechanical Handling, Storage and Conditioning of Solid Fuel," at 10 a.m. "Automatic Regulation of Combustion Conditions: Small and Medium-Size Boilers," by E. Burman. North Western Region. Engineers' Club, Albert-square, Manchester. Tues., Feb. 4.

Helicopter Association of Great Britain

LONDON
"Wind Tunnel Testing of Helicopter Models," by M. S. Hooper. Royal Aeronautical Society, 4 Hamilton-place, W.1. Fri., Feb. 7, 6 p.m.

Illuminating Engineering Society

CARDIFF
"Modern Applications of Plastics," by P. H. Collins. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Feb. 6, 6 p.m.
EDINBURGH
"Modern Trends in Cold Cathode Lighting," by E. A. Langsdon. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Feb. 5, 7.30 p.m.
GLASGOW
"Modern Trends in Cold Cathode Lighting," by E. A. Langsdon. Glasgow Centre. Lighting Service Bureau of Scotland, 29 St. Vincent-place, Glasgow, C.1. Thurs., Feb. 6, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Lighting Research at the Building Research Station," by R. G. Hopkinson. Newcastle-upon-Tyne Centre. King's College, College-road, Newcastle-upon-Tyne. Wed., Feb. 5, 6.15 p.m.

Incorporated Plant Engineers

LONDON
"Some Responsibilities of the Civil Engineering Contractor's Plant Engineer," by Colonel J. H. Brass and R. H. McGibbon. Royal Society of Arts, John Adam-street, W.C.2. Tues., Feb. 4, 7 p.m.*
EDINBURGH
"Testing of Engineering Materials, Destructive and Non-Destructive, by Mechanical, Chemical, X-Ray and Ultrasonic Means," by J. A. Menzies. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Feb. 4, 7 p.m.
GLASGOW
"Some Factors Concerning Works Capital Expenditure," by F. Franklin. Glasgow Branch. Scottish Building Centre, 425/427 Sauchiehall-street, Glasgow. Thurs., Feb. 6, 7.15 p.m.
LEICESTER
"Trade Waste Effluents," by S. J. Roberts. Leicester Branch. Bell Hotel, Leicester. Wed., Feb. 5, 7 p.m.
PETERBOROUGH
"Optical Engineering," by J. Hobbs. Peterborough Branch. White Lion Hotel, Church-street, Peterborough. Tues., Feb. 4, 7.30 p.m.
SOUTHAMPTON
"Training the Young Engineer," by H. Nobes. Southern Branch. Polygon Hotel, Southampton. Wed., Feb. 5, 7.30 p.m.

Institute of Fuel

CARDIFF
"Some Aspects of Fuel Efficiency in Modern Blast Furnace Practice," by K. C. Sharp. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Feb. 7, 6 p.m.

Institute of Marine Engineers

BIRMINGHAM
Annual General Meeting. "Developments in Marine Electrical Installations, with Particular Reference to Alternating Current Supply," by A. N. Savage. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Feb. 13, 6.30 p.m.
LIVERPOOL
Annual General Meeting. "Materials for Superheater Tubes and Supports," by D. W. Crancher. Merseyside and North Western Section. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Mon., Feb. 3, 6 p.m.

Institute of Metals

LONDON
"Corrosion by Liquid Metals," by Dr. B. R. T. Frost. London Local Section. Thurs., Feb. 6, 6.30 p.m.
BIRMINGHAM
"Porous and Infiltrated Metals," by J. E. Elliott. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., Feb. 6, 6.30 p.m.
OXFORD
"Technical Control of Some Metal-Working Processes," by Professor A. R. E. Singer. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Feb. 4, 7 p.m.

Institute of Petroleum

LONDON
"Mechanism of Sludge Suspension in Engine Oil," by Dr. P. J. V. Agius and D. Mulvey. Wed., Feb. 5, 5.30 p.m.*

Institute of Refrigeration

LONDON
"Preservation of Living Cells and Tissues at Low Temperatures," by Dr. Audrey U. Smith. Junior Institution of Engineers, 14 Rochester-row, S.W.1. Thurs., Feb. 6, 5.30 p.m.*

Institute of Road Transport Engineers

BRISTOL
"Research on the Testing and Performance of Commercial Vehicle Brakes," by Dr. H. J. H. Starks. Western Centre. Royal Hotel, Bristol. Wed., Feb. 5, 7 p.m.
GLASGOW
"Wear and Tear," by J. E. Johnson. Scottish Centre. 39 Elmbank-crescent, Glasgow, C.2. Mon., Feb. 3, 7.30 p.m.
LIVERPOOL
Discussion on "The Operation of Commercial Vehicles Overseas." West Regional Centre. Liverpool Architectural Society, Bluecoat Chambers, School-lane, Liverpool. Tues., Feb. 4, 7.30 p.m.

Institution of Chemical Engineers

LONDON
Papers on "Turbulent Flow of Suspensions in Pipes;" "Sedimentation and Fluidisation"—Part II; and "Mass Transfer Between Fluidised Particles and a Gas." Geological Society, Burlington House, Piccadilly, W.1. Tues., Feb. 4, 5.30 p.m.*

Institution of Civil Engineers

LONDON
"Use of Aerial Photography by Railways," by N. E. V. Viner-Brady and H. M. Pearson. Tues., Feb. 4, 5.30 p.m.*
MANCHESTER
"Some Developments in Scottish Hydro-Electric Power," by R. Freer. North Western Association. Engineers' Club, Albert-square, Manchester. Thurs., Feb. 6, 6.30 p.m.

Institution of Electrical Engineers

LONDON
49th Kelvin Lecture on "High Polymers," by Sir Harry W. Melville. Thurs., Feb. 6, 5.30 p.m.*
CHESTER
"Domestic High-Fidelity Reproduction," by J. Moir. Mersey and North Wales Centre. Town Hall, Chester. Mon., Feb. 3, 6.30 p.m.
DERBY
"Automatic Circuit Reclosers," by G. F. Peirson, A. H. Pollard and N. Care. East Midland Centre. Offices of the East Midlands Electricity Board, Derby. Tues., Feb. 4, 6.30 p.m.*
LEEDS
"Full-Scale Stability Tests on the British 132 kV Grid System," by Dr. F. Busemann and W. Casson. North Midland Centre. 1 Whitehall-road, Leeds. Tues., Feb. 4, 6.30 p.m.

Institution of Electrical Engineers and British Nuclear Energy Conference

LONDON
"Temperature Transients in Gas-Cooled Thermal Nuclear Reactors," by J. H. Bowen and E. F. O. Masters; "Application of Digital Computers to Nuclear-Reactor Design," by Dr. J. Howlett; and "Boron-Trifluoride Proportional Counters" and "The Design, Performance and Use of Fission Counters," by W. Abson, P. G. Salmon and S. Pyrah. I.E.E., Savoy-place, W.C.2. Tues., Feb. 4, 5.30 p.m.*

Institution of Heating and Ventilating Engineers

LONDON
"Oil Burning Equipment," by C. A. Roast. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Feb. 5, 6 p.m.*

Institution of Highway Engineers

LONDON
Discussion on "Planting and Control of Road Verges," 11 Upper Belgrave-street, S.W.1. Fri., Feb. 7, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "Dry Lubrication." Lubrication Group. Thurs., Feb. 6, 6 p.m.*
ABERDEEN
Thomas Lowe Gray Lecture on "Machinery in Cross-Channel Passenger Ships," by E. L. Denny. Scottish Branch. Robert Gordon's College, Aberdeen. Fri., Feb. 7, 7.30 p.m.
COVENTRY
"Training of Automobile Engineers," by J. Wilson. Coventry A.D. Centre. St. Mary's Hall, Coventry. Wed., Feb. 5, 7.15 p.m.
GLASGOW
Thomas Lowe Gray Lecture on "Machinery in Cross-Channel Passenger Ships," by E. L. Denny. Scottish Branch. Royal College of Science and Technology, Glasgow. Thurs., Feb. 6, 7.30 p.m.

Institution of Production Engineers

BRISTOL
"Technical Education for Production Engineers," by Lord Hives. The University, Bristol. Thurs., Feb. 6, 6.30 p.m. (Tickets required.)

Institution of the Rubber Industry

LEICESTER
"New Applications for the Engineering Properties of Butyl Rubber," by R. F. Neu. Leicester Section. Bell Hotel, Leicester. Thurs., Feb. 6, 7.30 p.m.
PRESTON
"Comparison of Different Types of Heating in the Rubber Industry," by J. R. Happer. Preston Section. Bull and Royal Hotel, Church-street, Preston. Mon., Feb. 3, 7.15 p.m.

Institution of Structural Engineers

CARDIFF
"Structural Aspects of the Design of a Sea Outfall," by C. D. C. Braine. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Feb. 4, 6.30 p.m.
MIDDLESBROUGH
"Structural Aspects of Nuclear Reactors," by W. H. Chilton. Northern Counties Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., Feb. 4, 6.30 p.m.*
NEWCASTLE-UPON-TYNE
"Structural Aspects of Nuclear Reactors," by W. H. Chilton. Northern Counties Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Feb. 5, 6.30 p.m.*

Junior Institution of Engineers

LONDON
Films including "Wickman Erodomatic." Fri., Feb. 7, 7 p.m.*

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Tip Clearance and Shrouding Effects in Axial-Flow Compressors," by R. C. Turner and J. L. Jefferson. Mining Institute, Newcastle-upon-Tyne. Fri., Feb. 7, 6.15 p.m.

Reinforced Concrete Association

BIRMINGHAM
"Use of Prestressed Concrete for Long-Span Slabs (20 ft. to 60 ft.)," by F. J. Samuely. Midland Counties Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Feb. 4, 6 p.m.*

Royal Society

LONDON
Discussion on "Experimental Results with the Zeta Apparatus on Controlled Thermonuclear Reactions," opened by Sir John Cockcroft. Wed., Feb. 5, 3 p.m.
"Growth and Evaporation of Crystals from the Vapour Phase," by S. A. Kitchener and R. F. Strickland-Constable. Thurs., Feb. 6, 4.30 p.m.*

Royal Statistical Society

LONDON
"Statistics in Management and Administration," by L. H. C. Tippett. London Industrial Applications Group. Institute of Physics, 47 Belgrave-square, S.W.1. Fri., Feb. 7, 6 p.m.*

Scientific Film Association

LONDON
"Discharge Lamps: Principles and Practice," by Dr. E. J. G. Beeson. Royal Photographic Society, 16 Princes-gate, S.W.7. Thurs., Feb. 6, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Vacuum Spectroscopy and X-Ray Fluorescence," by K. M. Bills. B.I.S.R.A. Laboratories, Hovle-street, Sheffield. Tues., Feb. 4, 7 p.m.

Society of Instrument Technology

CHELTENHAM
"Process Control in the Chemical Industry," by P. J. K. Simpson. Cheltenham Section. The Rotunda, Cheltenham. Fri., Feb. 7, 7.30 p.m.
FAWLEY
"Application of Modern Techniques to Automation," by J. Loxham. Fawley Section. Copthorne House, Fawley, Hants. Fri., Feb. 7, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Nuclear Energy Conference, Great George-street, London, S.W.1. (WHItehall 4577.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, 61 New Cavendish-street, London, W.1. (LANgham 2250.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

The Human Element

Steel Constructs a Readership

It has been announced by the Imperial College of Science and Technology that the British Steel Producers Conference and the British Constructional Steelwork Association have offered £6,000 a year at the Imperial College for the establishment of a readership in structural steelwork in the Department of Civil Engineering. This offer includes a number of postgraduate bursaries in the same subject. The University of London has approved the new readership and an appointment will be made shortly.

From the civil engineering point of view the new lectureship can be looked at from two aspects. It offers increased opportunity for research at the academic level in steel construction. Further, it ensures a flow of graduates who are trained in the academic side of steel fabrication and who will take themselves and their knowledge back into industry. Up to now the flow has been somewhat one sided for much more organised effort at the academic research level has gone into the cement side of civil engineering. The new readership will provide a channel by means of which the balance can be restored.

Absent from the Pit

A joint scheme has been prepared by the North West Area of the coal industry and the area branch of the National Union of Mineworkers to deal with chronic voluntary absenteeism. About 56,000 miners are involved. Each of the 71 pits in the area is to have its own attendance committees. There will be a committee consisting of equal representation from the management and the N.U.M. to deal with underground operatives and another consisting of equal numbers from management and the shotfirers' union to deal with junior officials underground.

If a man is suspected of persistent absenteeism the pit manager will be asked to examine his records. If the figures are bad he will be brought before the committee, warned and given a month's trial. If that is not enough he will be either recommended for down-grading or dismissal. The committees will not take disciplinary action themselves. That will be left to the management.

This experiment will be watched with great interest throughout the coalfields. If it is a success it may catch on although there has been already one blast of disapproval from another area. Clearly much depends on whether the committee can win the confidence of the men. If tact and patience are not used the committees will begin to look like a branch of management and treated accordingly. Meanwhile, the local union representatives are to be congratulated on their courage and imagination. It has been clear for some time that some middle way must be found among miners between mild exhortation on the one hand and the discipline of economic circumstances on the other if management-labour relations were to help solve the problem of rising costs.

Future of Arbitration

The first talks have now been held about the future of the Industrial Disputes Tribunal. This was set up in 1951 under a defence regulation to replace the wartime National Arbitration Tribunal. Under its terms strikes were once more made legal but it remained possible for either party to a dispute to refer it to the Ministry of Labour to have the issue brought before a tribunal.

About a year ago the Ministry let it be known that it proposed to do away with the remaining defence regulations and asked the employers and the unions for their views about the future of the Industrial Disputes Order. The Trades Union Congress have said that they would like the order to remain but if this could not be done to have the provisions embodied in legislation. The British Employers' Confederation take the view that there should be legislation which would take a dispute to a tribunal only if both sides wished it to be so.

The Government are now left to handle what could be an exceedingly controversial issue. Their task is none the easier since the T.U.C. and B.E.C. do not enjoy particularly cordial relations and this is the sort of issue where there could be a certain amount of awkwardness for the sheer pleasure of it.

Ataxia

A memorandum submitted to the Royal Commission on Doctors' and Dentists' Remuneration by the Engineers' Guild draws attention to the acute problems the engineering profession is facing due to " the maintenance of high rates of taxation in conjunction with a continually rising cost of living." The remuneration of the more senior engineers is found to be wholly inadequate and their standard of living—" the very impetus to advancement of the professional classes"—has correspondingly declined.

The Guild are concerned lest this decline in living standards dampens " the energy and enthusiasm of the professional classes " and reduces their capacity " to attract sufficient good recruits to meet (in engineering at least) their rapidly expanding commitments." The memorandum quotes the Chancellor of the Exchequer's budget statement of last year when he himself so clearly recognised the problem on hand: " the tax on young executives, on the men getting to the top positions, on scientists and nuclear technicians is too high . . . when they have worked hard and long it is not unreasonable that they should expect a fair proportion and, if possible, an increasing proportion, of what they earn." His successor, Mr. Heathcote Amory, doubtless takes the same view but the steam roller of uniformity is still with us. It is a courageous Chancellor who dares reverse the levelling down process of post war years when achievement has been at a discount.

There is of course the incentive of work well done, and the good man's inability to do less than his best but this is true also in other countries where financial rewards are given as well. The Guild's concern is for those members of the Institutions who " grin and bear it " in this country. But many are seeking opportunities abroad. Some 25 per cent. of the engineering students who go to North America on postgraduate fellowships do not return. Other young professional engineers—9 per cent. of the annual increase in the membership of the four leading Institutions—emigrate in search of a better deal. The British people, and the wage earners as much as any section of the community, should realise that unless their leaders and the creators among the educated few are properly rewarded, they will grow less and that the nation as a whole will suffer in the process.

Denmark's Way

A Danish professional engineer, writing in the January issue of the *Journal of the Engineers' Guild*, gives details of the education and training of engineers in his country. So far the aim has been to produce engineers " with a broad and thorough theoretical knowledge " acquired during four and a half years' study in theTechnical University of Denmark.

There is a shortage of professional engineers and to encourage promising mathematics or science students to enter the profession a new degree, " Licentiatus Technices," similar to the Ph.D., was introduced a few years ago. There is now a proposal by the University authorities for a second engineering education—" shorter in duration and less technical "—to meet the country's needs. A survey carried out in 1954 revealed that there were 1,900 professional engineers and 1,300 engineering technicians per million of the population and that each year the corresponding figures for new entrants to the profession were 82 and 86 respectively.

The Institution of Danish Civil Engineers is the dominant body in the profession, accounting for some 90 per cent. of all graduates in engineering. Its activities range widely from regular salary surveys to work on engineering specifications and standards and promotion of the exchange of young engineers among countries. It would seem from this account that the engineering profession in Denmark is very active and it is hardly surprising that 40 per cent. of all that country's exports now consist of engineering products.

Perpetual Motion

There is a growing feeling among trade unions that any increase in National Insurance contributions should be reflected in the level of wages.

The National Union of Mineworkers are the first to include this as a reason to justify their new pay claim. An extra 2*s*. a week is demanded over and above the rise in the cost of living to compensate the miners for the extra money they and other workers will have to pay in insurance stamps.

This is worrying the leaders of the Labour Party, and rightly so, for their national superannuation scheme will require substantially increased contributions from both employers and employees. Their proposals are an investment in old age, and must be paid for out of consumption. If the miners' attitude spreads to other unions it could wreck the whole scheme. This was admitted by Mr. R. H. S. Crossman at a Press conference announcing Labour's plans. The trade unions must learn that whatever party is in power the ability and the willingness of their members to save is the only means open to them to have a comfortable retirement.

Picking Out the Good Drivers

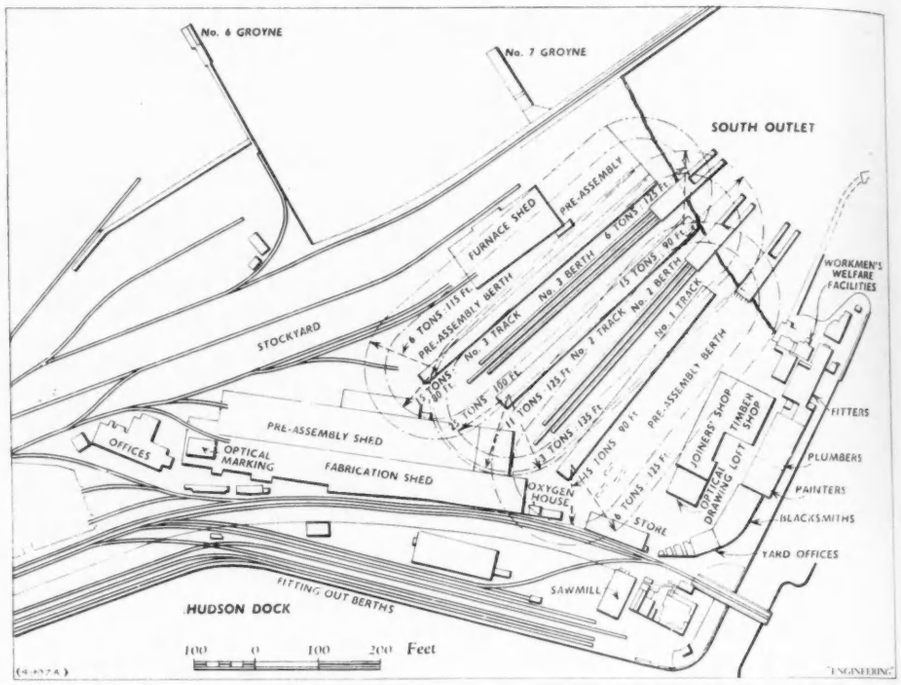
Men cling hard to their privileges, rights and reputations and few would willingly admit that woman should be classifiable as an " advanced motorist." Yet the first bulletin of the Institute of Advanced Motorists gives conditional praise to the weaker sex who are described as " in the main more conscientious and careful, and more ready to accept advice as to driving faults than men." After 18 months of its existence, the Institute has 5,380 members as a result of 8,349 tests conducted by its staff up and down the country.

Women candidates performed excellently and are well represented among the 64 per cent. who have been successful. The director of tests, Mr. George Eyles, comments that " some men flush red when their driving technique is in any way questioned, whereas a woman is ready to listen to criticism and learn to rectify her shortcomings." Disabled drivers are among the best, " because their disability makes them concentrate on their driving." The Institute, which is a non-profit making organisation, has aroused a great deal of interest and enquiries have been received from many countries with a view to establishing branches as a means of increasing safety on roads. Its appeal will be even greater if the insurance companies recognise the test as a qualification for a lower premium—from all accounts a justifiable step to take.

Special Article

BRITISH SHIPYARD WITH NEW IDEAS

Criticism for not using modern methods of construction is often levelled at shipyards. Some British yards, however, are adopting pre-fabrication and close planning of manufacturing time tables with great success. Where management-labour relationships are enlightened, remarkable advances in productivity have been achieved. What one firm, Bartram and Sons Limited, are doing at Sunderland is related below.



Layout of Bartram's yard at Sunderland, showing the route material must take from the stockyard through the fabrication and pre-assembly sheds, on to the assembly berth before being put into the vessels under construction.

FABRICATING, erecting and fitting-out of ships at a rate of 38 gross tons per annum for every man employed in the yard is an achievement comparable with the best in the world. It represents some 16 tons of steel per man and is a fair target for the effective use of manpower on the production of dry-cargo ships. It may well be that such figures are obtained at several yards in the United Kingdom, but the fact that they can be—and the circumstances under which they are—is well illustrated in terms of the activities of Bartram and Sons Limited, South Dock, Sunderland.

Bartram's are an old firm—they were established in 1837—and their yard is not a new one, though it is in the process of fast being re-modernised, for the second time since 1943. Yet 38 tons gross per man is a figure that they have averaged over the last three years. They put their target for the immediate future at 40 tons and the limitation on output as the supply of steel plate; they are having to meet their present average output of 38,000 gross tons a year by buying a limited quantity of steel from either the Continent or America. With a labour force of around 1,000 and another 130 supervisory, drawing office and clerical staff, the output is around half-a-dozen vessels a year of all types. The majority of the vessels are 10,000-14,000 dry-cargo motor vessels (ranging from 425 ft. to 465 ft. between perpendiculars). Within the last two years there has also been a 17,000 ton tanker and a 14,000 ton ore carrier. In general, there is very little repetition work. Of the six vessels either just completed or about to be laid down, only the first and sixth are identical; this identity, however, makes for no saving in the shops or berths, for the first will have been commissioned before the sixth is begun.

The layout of the yard is shown in the accompanying plan. Steel comes in by rail and is stacked in the stockyard in the north-east part of the area. From stock, the steel is also at present moved on rail to the east end of the fabricating sheds, except frames and sections which have to go direct to the furnace shed on the north side of the berths. The plant in the fabrication shop is at this moment in the state of being replaced—of which more later—but there has been, and will be, the necessary equipment for straightening, drilling and countersinking the plate. Overhead cranes in the shed consist of two each with a capacity of 5 tons (one with magnetic pick-up) and one of 3 tons.

From the fabrication shed the steel is moved over into the adjacent pre-assembly shed. In this shed there are two 7½ ton gantry cranes which can be run out of the open west end of the shed and above the stacking area which is covered by two of the yard cranes. The floor space available in the pre-assembly shed (350 ft. by 60 ft.) is such that work can be done on about 20 large components (maximum individual weight, 15 tons) simultaneously. From the stacking area outside the shed, these components can be slung either directly into the ships under construction or on to the pre-assembly berth (the old No. 1 berth, now filled in) adjacent to No. 2 berth. Here, further fabrication can be undertaken up to the 15 ton capacity of the yard cranes (at their full reach of 125 ft. the lift is reduced to 6 tons; an additional 25 ton crane is on order as part of the re-modernisation scheme). A Coles 20 ton mobile crane is also used to great effect, handling sub-assemblies in this assembling and storage area.

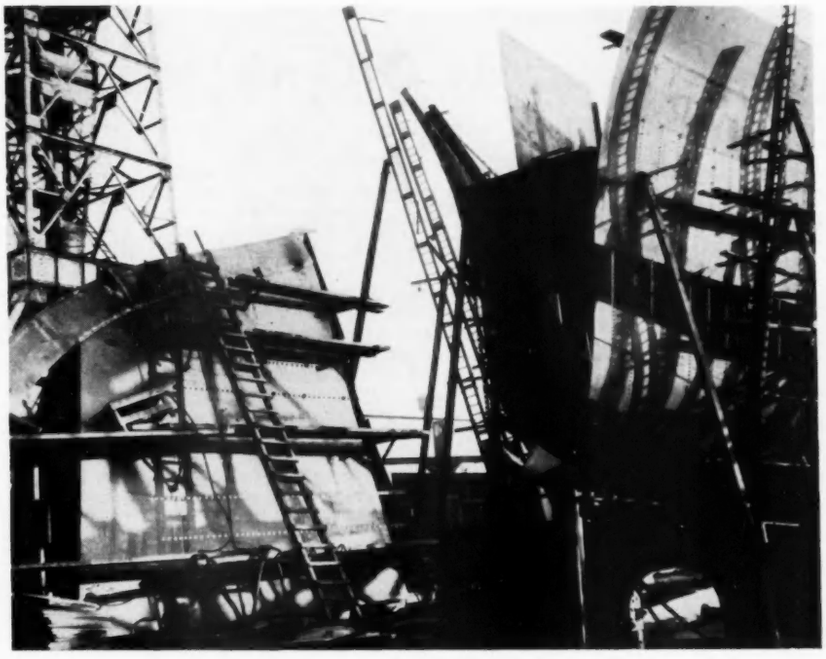
As will have been gathered, there are two berths available for construction; one of these can take a vessel of 480 ft. in length, the other one of 550 ft. Facilities at the yard are completed by a fitting-out berth with a 5 ton crane and one with a 40 ton lifting capacity for shipping engines, and a full range of shops for blacksmiths, painters, plumbers, fitters, electricians and joiners. The buildings which at present constitute these shops either have been, or are being, demolished and re-built—a prospect that does not make for easier planning or working in the period of reconstruction.

It is appropriate at this point to give some further breakdown of the figures for steel movements through the yard. Roughly speaking, each vessel spends some 14 to 16 weeks on the stocks and another 16 being fitted out. It is, however, the remarkable speed with which the steel moves from the stockyard to the construction berth which is so impressive. The programme is as follows. One day is allowed for drawing steel plate from stock and transferring it to the pre-fabrication shed. The second day is allowed for marking-out and cutting, followed by three more days for fabrication in the pre-assembly shed. Another day is then allowed for shifting sub-assemblies out on to the assembly berth. If, by then, the construction of the vessel has progressed sufficiently, the component can be put into the ship on the following day, making only seven days from stockyard to construction berth. In fact, of course, this rate cannot be maintained continuously and the pre-assembly berths adjacent to the construction berths necessarily become stacking yards. With the present throughput of 365 tons of fabricated steel per week (the average over the last three months) there is nearly 1,500 tons of steel on the move between the stockyard and construction berths.

It is interesting to look at these figures in terms of the labour force directly involved. Of the 610 steelworkers employed in the yard, 575 work on the vessel prior to launching; the remainder are concerned with fitting out. Of the 575, about 250 work in the stacking yard, fabrication, pre-assembly and furnace sheds, and 325 are engaged in the pre-assembly berths or are actually at work on the ships under construction. Only a single full day shift is worked but a night gang is used to transport work from one part of the yard to another.

The bulk of pre-assembly in the yard—around 90 per cent. of the fabrication—is by welding, riveting being restricted to riveting frames to shell plating, stringer angles connecting deck to shell, and a few minor connections which are more economical to rivet.

Welding equipment includes 16 six-operator sets and four twelve-operator sets (frequently worked economically with 18 welders per set) and appropriate transformers and regulators. Automatic welders installed include two Fusarc 1,000 amp. machines, two Lincoln 1,800 amp. Twinarcs, and two Fusarc CO_2 1,200 amp. machines for fillet welding. A comprehensive system of piped oxygen and acetylene is available throughout the shops, berths and fitting-out quay. Oxygen is taken from liquid-oxygen tanks and



the acetylene is kept in batteries of 16 × 250 cub. ft. bottles.

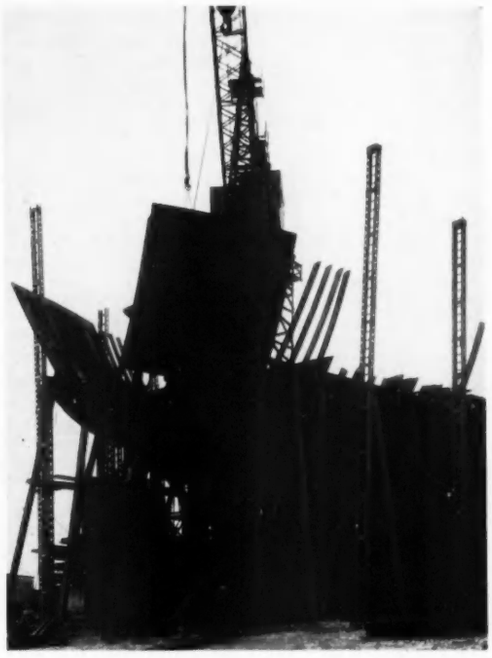
The furnace shed, with its oil-fired furnace, is able to cope with 60 ft. long frames and minor webs and bulkheads are made in this shed and hand sheared. A 3 ton gantry crane is used to handle material. For all vessels, the longitudinals are made up in this shed as well as transverses for oil tankers, these having been previously flame-cut in the fabrication shed.

Equipment alone, modern or otherwise, does not make for productivity. Objective designing, with the yard facilities and limitations kept clearly in mind, is a first necessity; so is good planning, particularly progress planning, in order to make full use of working space without cluttering up the yard with sub-assemblies that cannot be erected. In this respect, the planning department at Bartram's is evolving some original diagrams and marking systems for progress chasing.

And finally, such innovations as these, through a yard that has behind it more than a century of traditional shipbuilding, are not possible without first-class management-labour relations. Consider the position: the template loft, keystone in traditional shipbuilding, done away with; new and faster machines being constantly brought into use; the order of building being continually amended so as to get work off the berths and into the shops; all this is not possible if there are marked differences between the management and labour. Integration of manufacturing units may be the solution in some areas of industry, but there is much to be said for the firm which is compact enough to maintain a well-informed and progressive labour force.

(Above) Assembling the fore peak unit close to the hull. When completed for erection the unit weighs 28 tons and both the yard cranes will be required to turn it over and sling it into position.

(Right) Erection of the aft-end shell panels. Using pre-fabrication methods, Bartram's have 14,000-ton general dry-cargo vessels on the stocks for about 3 to 4 months.



The latest vessel to be launched is the m.v. North Devon. She is a single-screw motor cargo vessel of 11,500 d.w. tons for the tramp trade, built for the North Shipping Company Limited. She entered the water after having been on the slips for only 11½ weeks.

AIRCRAFT SEEK NEW EQUILIBRIUM

Seldom can the necessity of radical change have thrust itself so quickly and so completely upon an industry as it has on the aircraft industry during the past few months. Basically it is the withdrawal of Government funds for research and development, coupled with a severe pruning of orders for military aircraft and the urgent need for the development of new civil aircraft, which precipitated the present crisis. The industry was sustained by the re-armament programme; once it had been decided to cut back this programme the need for a major reorganisation of the industry became inevitable. But there were other causes, which made it even more difficult for companies to adapt themselves to conditions under which practically all new work had to be undertaken as "private venture." The guided missile made the manned aircraft almost obsolete as a striking or interceptor weapon; the large transport aircraft flying at near-sonic speeds made the small to medium-size aircraft equally obsolete. This is not to say that manned military aircraft will be eliminated within a very short time: a vice-president of the Boeing Airplane Company said recently that they would continue to be the backbone of the United States air force "for many years to come." Yet, as Sir Thomas Sopwith has said, that "future requirements will not be for so many types or so many aircraft of each type."

The other two major changes relate to radical departures in aircraft design and construction and to the major developments in recent months in astronautics, the study of locomotion outside the atmosphere. Aircraft speeds were rising, with every prospect of transonic speeds of Mach 3 to 5 within a decade rather than the Mach 1½ to 2 currently envisaged. This means the use of radically different materials and methods, with consequent changes in production techniques. Conventional fasteners are giving way to spot-welding, brazing and fusion welding. New alloy steels, molybdenum, fused quartz, ceramics, cermets and high-temperature plastics are entering the arena. All this means an increased need for research, with considerably less public finance than hitherto. Sir Thomas Sopwith states the problem quite simply "Most of our understanding and experience of flight comes from its application to defence. Civil aviation has benefited considerably by the urgency and the resources with which the military problem has been pursued. We are now suddenly faced with the prospect of being deprived of this advantage. In many fields of aeronautics research seems likely to contract or run down." The logical consequence is larger, more powerful manufacturing units, with a wide industrial base and able to operate internationally. The need to hasten progress in astronautics, so important politically and for reasons of national safety, further underlines the inevitability of regroupment and rationalisation.

Atomic Review

Neutrons Call the Tune

WHETHER it be fission or fusion, neutrons call (or at least identify) the tune. Were it not for the property that a few neutrons are evolved when certain heavy elements are split, there could be no chain reactions and no Calder Hall. To demonstrate that deuterium nuclei have fused together in Zeta and other thermonuclear apparatus, neutrons must be emitted and their origin identified. Whatever developments may occur in the peaceful applications of atomic energy, the measurement of neutron flux will continue to play an important part. It will also be necessary to protect instruments and personnel from neutrons and other radiation.

Zeta

The significance of neutrons in the identification of thermonuclear reactions has already been discussed in Atomic Review; and in Zeta the Zero-Energy Thermonuclear Assembly at Harwell, the neutrons emitted are considered to be almost certainly thermonuclear in origin. Zeta is described in detail on page 134 of this issue, and a background to recent news on thermonuclear fusion appeared in Atomic Review last week; a list of references was also published. An article, entitled "Controlled Thermonuclear Reactions," by Dr. A. A. Ware, of the A.E.I. Research Laboratory, Aldermaston, where studies have also been carried out, was published in ENGINEERING last November 15 (page 610) and provided a full introduction to the subject.

Credits

The work on Zeta has been carried out in the General Physics Division at Harwell, which is under the direction of Mr. D. W. Fry. The group responsible for the work has been led by Dr. P. C. Thonemann and senior members concerned with Zeta have been Mr. R. Carruthers and Mr. R. S. Pease, with Mr. J. T. D. Mitchell of the Engineering Division, and Dr. W. B. Thompson of the Theoretical Physics Division. The fusion of deuterium nuclei was first achieved in 1932 by Sir John Cockcroft and his colleagues at the Cavendish Laboratory, Cambridge, by speeding deuterons up to high energies and bombarding a deuterium-containing target.

Contractors

The following companies have contributed in the construction of Zeta:

Metropolitan Vickers Electrical Company Limited (Manchester): main contractors for construction of Zeta and collaborators in the design.
Telcon Magnetic Cores Limited (Glasgow): large ring type transformer cores.
Permali Limited (Gloucester): insulating and supporting material for transformer.
Wm. Beardmore and Company Limited (Glasgow): heat treatment of large transformer cores.
A. E. Cawkell (Electronic Engineers) (Southall): special electronic equipment.
Edison Swan Electrical Company Limited (Glasgow): electric cables.
Standard Telephones and Cables Limited (Harlow): rectifier equipment.
British Insulated and Callender's Cables (Helsby): condensers.
Lee and Wilkes Limited (Birmingham): copper tubes.
George King Limited (Stevenage): cranes and hoists.
Dynamo and Motor Repairs Limited (Wembley Park): motor-generator set.
W. E. Chivers Limited (Devizes): building work.
British Thompson-Houston Company Limited (Rugby): ignition switches.

Speculation on Unlimited Power

It is argued that the successful exploitation of fusion energy cannot mean much reduction in the cost of power. The separation of the deuterium fuel from sea water is an avidly energy-consuming process and now comparatively expensive at 2*s*. per gm. of separated deuterium; energy losses in the reactor would also add considerably to the cost. What is more, only a small proportion of the price of power to the consumer is attributable to the dower-producing plant. The advantage of fusion fuels would then be simply in their inexhaustibility as distinct from coal, oil, uranium and thorium.

On the other hand, since energy is the fundamental commodity required for the separation process, and indeed for every other industrial activity, including the capital construction of power plants and distribution systems, the effect of energy feedback to the processes of energy production might bring cumulative economies. The economic consequences of virtually unlimited power resources are therefore not immediately foreseeable. An entirely novel situation might arise in which limitations other than power supplies would become dominant.

Glossary of Thermonuclear Terms

Deuterium (or heavy hydrogen). Ordinary hydrogen is made up of two isotopes, that is, two different kinds of hydrogen atoms which differ mainly in weight. The heavier isotope, called deuterium, or heavy hydrogen, is present in small proportion only (about one in 3,000).

Deuteron. The nucleus of a deuterium (or heavy hydrogen) atom; it is formed by stripping the planetary electron from the atom (see also hydrogen ions).

Döppler Effect. If the atoms of a gas are emitting light in a narrow band of frequencies then the width of the band will increase as the temperature of the gas increases, because the speed of movement of the atoms also increases. This effect (analogous to the change in the note of an engine whistle when a train passes through a station) is called Döppler "broadening." This broadening can be used to calculate the temperature of the emitting gas.

Heavy Hydrogen. (See deuterium.)

Hydrogen Ions (or heavy hydrogen ions). Ions are atoms which have become charged by gaining or losing planetary electrons. In ZETA atoms lose their electrons and so become positive ions; thus hydrogen and deuterium atoms in the gas discharge lose their single planetary electrons and become positive ions called protons and deuterons, respectively. Atoms with more planetary electrons do not lose all their electrons so readily; thus the additive gases used to measure temperature lose some but not all of their electrons.

Line Spectrum. Atoms, or ions which still have planetary electrons emit radiation only in very narrow and widely separated frequency bands. These appear when photographed as widely separated narrow black lines; this gives rise to the name "line spectrum." Fully ionised atoms (that is, atoms which have lost all their planetary electrons) do not emit line spectra.

Thermonuclear Neutrons. Neutrons which are emitted from a true thermonuclear reaction. (See below.)

Thermonuclear Reaction. The atoms (or molecules) of a gas are always in random motion. As the gas is heated up the speed of this motion increases. For a nuclear fusion reaction to take place the colliding nuclei must possess considerable energy, that is, be travelling very fast. If a gas is so hot that the speed of random motion in it provides sufficient energy for nuclear fusion to take place, then a thermonuclear reaction is said to occur. Neutrons produced in thermonuclear reactions are called thermonuclear neutrons. One million degrees centigrade is the lowest temperature at which any measurable number of thermonuclear reactions could be observed.

Tritium. (See deuterium.) Tritium is a radioactive isotope of hydrogen which has three times the weight of the ordinary hydrogen atom. It is manufactured by bombarding an isotope of lithium with neutrons. It has a half-life of 12¼ years and decays by emitting beta particles (electrons).

Zero Energy. A zero-energy thermonuclear apparatus is one in which the thermonuclear power output is very small (even though the initiating power input is large).

Instruments and Radiation

Radiation Damage to Electronic Components

The effect of nuclear radiation on electronic components was one of the subjects of the International Symposium on Electronic Components, held at the Royal Radar Establishment, Malvern. In a paper "Nuclear Radiation Damage to Electronic Components," Mr. E. H. Cooke-Yarborough, of A.E.R.E., Harwell, discussed the exposure of certain components to radiation close to a pile, in the interior of a pile, and in the neighbourhood of a nuclear explosion. The last case gave conditions of a severity intermediate between the other two, which could be regarded as extremes.

The author summarised the kinds of radiation that were to be found under the various conditions. Close to a reactor—outside the shielding—the radiation intensity appears to have no destructive effects either upon normal equipment or, so far as is known, upon the human body. In the neighbourhood of a bomb explosion—beyond the range of some 2,300 ft. that corresponded to "complete destruction" for a 20 kiloton bomb—the effects of heat and blast fall off relatively slowly but the specifically nuclear effects of neutron and gamma radiation fall off much more rapidly.

Exposure to a radioactive cloud as is found in carrying equipment through it by an aircraft is mainly due to gamma radiation. It was found that at 15,000 ft. an aircraft travelling through a cloud 90 seconds after the explosion could still take up a dose of 550*r* units, which would be lethal for a human being. Lack of data prevents adequate consideration of the effects of fallout on the ground. For larger explosions, the effects of the cloud are increased, mainly on account of the increased duration of exposure; effects increase very roughly with the cube root of the megatonnage.

Dosages in the interior of a reactor are much more severe, reaching the rate of some 10^{18} neutrons per sq. cm. and even 10^{20} in the very interior. But it is hardly likely that electronic equipment will be located in such positions.

Mr. Cooke-Yarborough said that the question often asked was what would be the effect of nuclear radiation on components in general. The question was too general and no answer could be given. Details of the intensity spectrum of the radiation and the time of exposure were necessary. The spectrum was physically speaking, of basic importance. As far as destructive power was concerned it ranged from alpha particles, which were very effective in imparting their energy, to the neutrino, which was barely perceptible. The most important radiations for the type of questions that arise in practice were neutrons and gamma rays, though the latter were chiefly effective by exciting beta radiation. The energy distribution of the particles could have great effect and, for the present, a crude distribution into high and low energy neutrons could not be accepted as adequate. Thus it was difficult to give experimental results that were of precise value.

In assessing the effect on electronic components of such highly varied doses, there was a further handicap in that the make-up of particular components was uncertain. Small traces of sensitive elements, which may be unknown to the manufacturer, may well increase the sensitivity to radiation. Some experiments have been made at Harwell. Mr. Cooke-Yarborough summarised the results as follows. The exposure of various components for one second in the BEPO reactor may be considered as a standard, giving a dosage of 10^{12} neutrons per sq. cm. (300*r*). This was considered as likely to be that which might in practice be met near an atomic explosion, but the gamma ray dosage would be lower. It will be realised that this refers to a likely exposure that would not lead to complete destruction of the equipment. The majority of the components tested withstood this exposure, though some change was found in electrolytic capacitors, tantalum and aluminium, and units enclosed in glass envelopes appeared to suffer some change. Otherwise the only vulnerable unit was the transistor and even here, while the properties changed, destruction was not necessarily complete and in certain respects performance might be improved. The final conclusion was that destruction of electronic components without other large-scale destructive

effects does not seem very likely, though changes in long period behaviour must be expected.

Reactor Instrumentation

An article by Mr. G. W. McKeith and Mr. A. Gray in the *Heaton Works Journal* brings out clearly the important part that instrumentation plays in reactor operations, both from the point of view of experiment and routine performance. For the safe operation of a power reactor it is essential that instruments should be employed to indicate both the power level and its rate of change. Fast response is an essential property of such devices since the power level, particularly at starting, may increase very rapidly; and a dangerous condition arise unless appropriate action is taken. The powers involved are determined by measuring the neutron flux and instruments that are available for this purpose are described in detail. It is also essential in a power reactor that any failure of the fuel supply should be detected as quickly as possible to avoid contamination of the coolant and the methods of doing this are dealt with. Further instruments are necessary for measuring the temperature of the fuel, the gas coolant, the graphite moderator and the reactor structure generally, while alarms and trip circuits must be provided to shut down the reactor automatically if conditions become abnormal. Sections of the article are reproduced below.

Flux Measuring Instruments.—For each fission which occurs in the reactor fuel thermal energy is released. Nuclear power is thus proportional to fission rate in the reactor and this in turn is a function of the neutron flux. This flux varies throughout the reactor core being maximum at the core centre and minimum at the edge. The neutron flux distribution throughout the core is almost independent of the total power so that measurement of the neutron flux at one position in the core can be used to indicate power level. Likewise, the pattern of the neutrons escaping from the core is unaffected by power level, so that a measurement of total power may be made in the flux adjacent to the core. In practice, with this type of power reactor, the thermal neutron flux is measured in a large graphite block, known as the thermal column, which is used to slow down or "thermalise" the fast neutrons escaping from the core and is situated between the reactor pressure vessel and the biological shield. . . .

Suitable assemblies are required on which to mount the various detectors. The fixed type of ion chamber assembly is used for chambers operating in the high flux range. At high powers the retractable type for chambers working in the low-flux range is withdrawn into the biological shield so as to reduce the induced activity in the chamber. The counter chambers are also mounted on a retractable assembly which can be withdrawn into the biological shield at high flux levels so as to prolong the life of the counter tube. Fig. 1 shows a section through the thermal column and biological shield and indicates the method of placing the neutron detectors.

Fission Product Detection.—Fission products contain the gases xenon and krypton which decay to caesium and rubidium, respectively, which further decay by beta emission. This beta emission can be detected and used as a measure of the xenon and krypton concentration in the coolant and hence an estimate made of the area of uranium exposed in a fuel-can fault. By means of a complex system of pipework and selector valves a small quantity of gas coolant is drawn off from the fuel channels in turn and passed through a suitable filter to a precipitation chamber through which passes a fine wire held at a high potential. The beta emitting particles are precipitated on to the wire, which is then passed through a beta scintillation detector and the current pulses which are produced in the detector are counted in a ratemeter for a known period of time. The ratemeter output, which is proportional to the xenon and krypton concentration in the coolant sample, is presented on a multipoint recorder so as to obtain a permanent record. In the event of a high count reading on the ratemeter an alarm is given and the faulty channel or channels indicated on instrument panels in the control room. A schematic diagram of the fission product system is shown in Fig. 2.

Gridded Ionisation Chamber

A gridded ionisation chamber may be used for the accurate measurement of alpha particle energies, since in this type of instrument the output pulse is proportional to the initial ionisation. The high geometry (50 per cent.) makes it very suitable for analysing low activity samples or samples with low specific activity so that total activity is limited by source thickness. The six-position turntable incorporated in this instrument enables a calibration and background to be effected under conditions identical with those used for the sample under investigation.

A counter based on the principles outlined in the summary above was built to the design of G. Hanna and B. Harvey of Chalk River. (Mrs. K. M. Glover: A.E.R.E. C/R 2091, price 3*s*.)

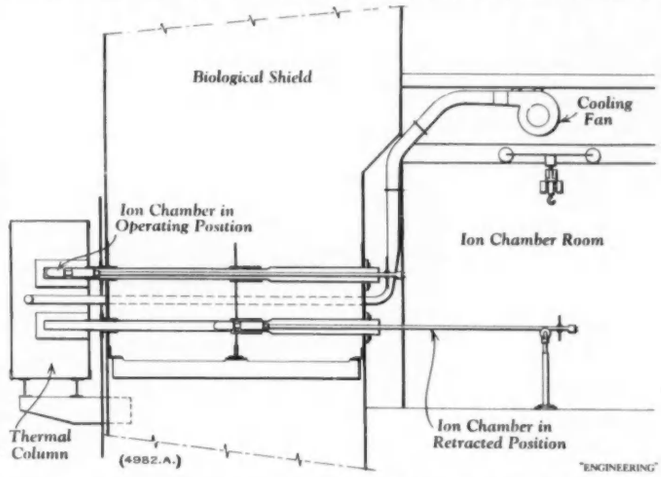


Fig. 1 (right) A section through the thermal column and biological shield of a nuclear reactor, showing method of placing the neutron detectors.

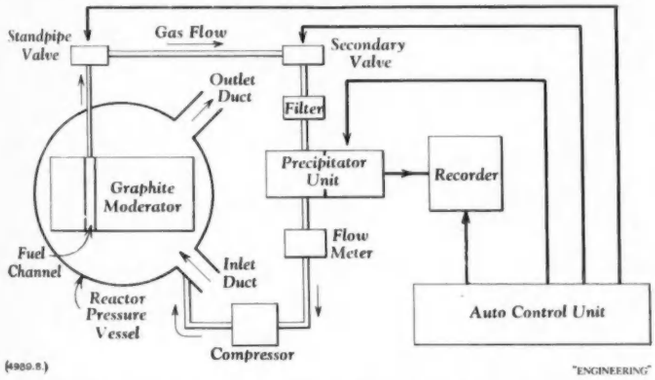


Fig. 2 (below) Arrangement of a fission-product detection system for a gas-cooled reactor of Calder Hall design.

Control of Diverging Reactor

In the design of automatic control systems which operate a diverging reactor, for example automatic start-up systems, a knowledge of the transfer function of the reactor is required. General expressions for the gain and phase shift of a steadily diverging reactor as functions of frequency are derived in an Atomic Energy Research Establishment report. Numerical values have been computed for a reactor with six groups of uranium 235 delayed neutrons. Doubling times of 1, 5 and 20 seconds and mean neutron lifetimes of 10^{-3}, 10^{-4} and 10^{-5} sec. have been considered and results for these values are shown graphically.

The results obtained in this theoretical study show that the transfer function of a diverging reactor is significantly different from that of a reactor in the steady state. The differences are of such a nature as to decrease the phase and gain margins of stability of the control system. The additional stability margins required can be found from the graphs. (R. Potter: A.E.R.E. R/R 2245.)

General Notes

Homogeneous Reactor Critical

The Homogeneous Reactor Experiment No. 2 (HRE-2), an experimental power reactor of the United States Atomic Energy Commission, has started up at Oak Ridge National Laboratory. It became critical last December 27, becoming the sixth experimental full-scale power reactor to go into operation in the United States during 1957. The reactor is of the aqueous homogeneous type, utilising a solution or suspension of nuclear fuel in water which serves as coolant and moderator. The homogeneous reactor is one of the five reactor types included in the Commission's original civilian nuclear power reactor development programme adopted in 1954.

The HRE-2 is a two-region reactor consisting of a core filled with a heavy-water solution of uranyl sulphate surrounded by a blanket containing heavy water as its initial loading. The fuel solution is pumped under pressure through the reactor vessel where it is heated by uranium fission, then through heat exchangers where the heat is released to produce steam. The steam can be used to drive a conventional turbine-generator to produce electricity. The reactor plant includes chemical processing equipment for purifying the irradiated fuel solution by continuously removing solid corrosion and fission products.

The HRE-2 project represents an advance in physical size and in technology over the HRE-1, which in 1953 became the second United States reactor to produce electric power from nuclear energy. HRE-2 is located below ground level at the Oak Ridge National Laboratory on the same site as HRE-1 which was dismantled in the spring of 1954. HRE-2 has a heat output of 5 MW. Most of the heat produced will be dumped to the atmosphere. The remainder will be supplied to a small turbine-generator to produce 300 kW of electric power. The generator is the same one used to produce power with HRE-1. The Oak Ridge National Laboratory, which is operated for the Commission by Union Carbide Nuclear Company, designed, developed and installed the nuclear reactor. Reference to the HRE project was made in Atomic Review on page 796, June 21, 1957, and page 154, February 1, 1957.

EBWR Power Doubled

The Experimental Boiling Water Reactor (EBWR) at the Argonne National Laboratory of the Atomic Energy Commission, Lemont, Illinois, has been successfully operated at a power level of 50 MW of heat, more than double its design level. The 50 MW level was attained December 23, 1957, with no change in the number or the arrangement of the fuel elements within the reactor core. Such an increase in the thermal output would potentially increase the plant's electrical output. An increase in the electrical output would theoretically

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make possible a reduction in the cost of the electricity.

In the case of the experiments in connection with the EBWR the electrical output was increased only to 6,250 kW, which is the maximum capacity of the turbine-generator portion of the plant. The amount of heat in excess of that required to produce the 6,250 kW was disposed of by condensing in the plant's main condenser the excess steam that was generated.

The EBWR was designed to produce 20 MW of heat and 5 MW of electricity with natural circulation of the core coolant. This original design power level and electrical output were achieved December 29, 1956, shortly after the reactor was first placed into operation. The 50 MW (thermal) operating level was achieved with natural circulation of the water coolant in the core of the reactor. The water was caused to boil at a higher than normal rate, resulting in faster circulation through the core and in a more rapid removal of heat.

It is believed, on the basis of the tests made, that the maximum stable power of which the present EBWR is capable may be still higher than that achieved. In addition, calculations by Argonne scientists and engineers indicate that with modifications the EBWR could produce up to 100 MW of heat and 25 MW of electricity.

This level of operation would require the addition of more fuel and a turbine-generator and condenser of larger capacity than those of the present plant. The EBWR is the first nuclear reactor built by the U.S.A.E.C., having as one specific purpose the experimental generation of electricity. Power generated by the EBWR is consumed at the Argonne National Laboratory which is operated for the Commission by the University of Chicago. Reference to EBWR was made in Atomic Review on page 153, February 1, 1957.

After the Fleck Report

It has been announced that the Prime Minister intends to appoint Mr. W. R. J. Cook, present Deputy Director of the Atomic Weapons Research Establishment of the United Kingdom Atomic Energy Authority, to be full-time member of the Authority. This makes it possible to progress towards certain alterations in the structure of the Authority. Three full-time members of the Authority have hitherto each had three types of responsibility. Firstly, they have had executive control of one or more of the Authority's Establishments. Secondly, they have been responsible for formulating policy on and for broad oversight of the subjects constituting their own special fields (research, production and engineering, and weapons). Thirdly, they have had to join, with their colleagues, in considering and deciding jointly on the general policy to be pursued by the Authority.

The purpose of the alterations is to free these members from their executive duties and thus enable them to devote more time to their other responsibilities. Sir John Cockcroft, who has since the setting up of the Authority held the posts of Member for Scientific Research and Director of the Atomic Energy Authority, will be succeeded in the latter post by Dr. B. F. J. Schonland, the present Deputy Director of A.E.R.E. Mr. Cook will be responsible at Board level for policy questions concerning the Authority's factories and the engineering aspects of the Authority's work. Since Sir Leonard Owen was appointed Managing Director of the Industrial Group in 1957 he has had executive charge of the establishments in that group. Sir William Penney will continue to be Member for Weapons Research and Development, and pending the appointment of a new Director of A.W.R.E. he will continue to hold that post also. The duties of Sir Donald Perrott (Member for Finance and Administration) and Mr. W. Strath (Member for External Relations and Commercial Policy) are unchanged. Mr. Cook and Dr. Schonland will take up their new appointments on February 17, 1958.

In Parliament

SCOTLAND'S HOUR

When Parliament resumed its sittings on January 21, after the adjournment on December 20 for the Christmas recess, many of the first questions to be answered in the House of Commons related to Scotland and Scottish affairs.

Technical education came in for a good deal of attention. Replying to a request from Mr. William Ross (Labour) for a statement on the promised provision of technical colleges in Ayrshire, Mr. Niall Macpherson, Joint Under-Secretary of State for Scotland, said that, since the end of July, discussions had continued between the education authority and the Scottish Office on matters relating to the suggested colleges at Ayr and Kilmarnock. A public inquiry had been held regarding the compulsory acquisition of the selected site for the Kilmarnock college and the report of the commissioner appointed to hold the investigation was now being awaited. Discussions were continuing about the accommodation to be provided there.

So far as the accommodation at the Ayr college was concerned, agreements had been reached and proposals would shortly be presented to the appropriate committee of the education authority.

TECHNOLOGICAL EDUCATION

Later, Mr. Niall Macpherson told Mr. Cyril Bence (Labour) that, of the £10 million authorised to be spent on buildings in Scotland for technical education, the Secretary of State had already approved projects to the value of £7,300,000. Further projects, to the value of £1,200,000, were at present under consideration and it was expected that projects covering the remaining £1,500,000 would be submitted to the Scottish Office very shortly. Every opportunity was being taken, by means of conferences and other forms of publicity to encourage employers and young workers to make full use of the facilities available.

In reply to a plea by Mr. George Thomson (Labour) that Scottish educational certificates should be equated with those of England and Wales, Mr. Niall Macpherson said that the differences between Scottish and English educational certificates reflected the differences between the two educational systems. It was undesirable, therefore, to make the Scottish pattern conform exactly with that of England. It was entirely within the discretion of individual professional and similar bodies to fix the entrance qualifications which they regarded as necessary, but the Department of Education in Scotland took a great deal of trouble to make certain that proper weight was attached to the Scottish certificates.

SMOKE CONTROL AREAS

Steady progress is being made regarding the provision of smokeless zones in Scotland, according to information given to the House by Mr. J. Nixon Browne, who is also a Joint Under-Secretary of State for Scotland. He told Mr. William Hannan (Labour) that, although no such zones had yet been established, three local authorities had submitted their preliminary proposals to the Secretary of State for setting up four smoke control areas under the Clean Air Act, 1956. Furthermore, these proposals had been approved in principle. Five other local authorities had notified the Scottish Office of their intention to set up such areas.

A memorandum outlining the relevant procedure had been sent last year by the Secretary of State to all local authorities. Surveys were now being conducted in a very large number of areas and these investigations were bound to take time. As to the availability of solid smokeless fuels, the House had been informed in March last that supplies were sufficient to meet not only existing demands, but likely demands in the immediate future. The Secretary of State had no reason to suppose that any proposals for smoke control areas put forward by Scottish local authorities would have to be rejected for lack of solid smokeless fuel. All possible steps would be taken to ensure that supplies were adequate, so that no one might be in a position to plead shortages of the right fuel as a defence for allowing smoke to be emitted in a smokeless zone.

LOOKING AFTER CANADIAN BUYERS

On the benefits likely to accrue to Scotland from the recent visit to Britain of Canadian industrialists, Mr. Niall Macpherson said that it was hoped that the contacts made by the Canadian mission would result in substantial increases in exports from Scotland, as from other parts of the United Kingdom. The purpose of the mission, however, was not to place orders. It was a fact-finding body whose objects were to obtain a first-hand knowledge of the achievements of British industry and to make recommendations with a view to expanding trade between Canada and this country. The mission had been exceedingly welcome in Scotland and it was believed that its members had formed a favourable impression of Scottish industry.

Mr. Malcolm MacPherson (Labour) urged the Minister to make sure that there was a definite follow through and that some attention was paid to the business about which there had been so much complaint, namely, Britain's selling organisation and our selling methods in Canada. Efforts should be made to see that Britain's industry cashed in on the good impression it had secured. Mr. Niall Macpherson undertook to convey these observations to his chief.

Light Castings in Falkirk

It was affirmed by Mr. Malcolm MacPherson that a depression set in every year in the light castings industry in the Falkirk area, which lasted from about January until the late summer. Mr. Niall Macpherson said that close touch regarding employment problems in that industry was being maintained with the Minister of Labour; and also with the President of the Board of Trade, who would bear in mind the needs of the Falkirk area for suitable new trades. Industry in the area as a whole had been adapting itself with very great success. About two dozen developments had taken place in the district since the war.

Help for Under-Developed Areas

As much assistance as possible is being given by Britain, and will continue to be given, towards the development of her dependent overseas territories and of other under-developed countries. Mr. R. A. Butler, the Lord Privy Seal, told the House that assistance of this kind from Exchequer funds alone had amounted to £230 million during the last three complete financial years. The recent Russian offer at Cairo to provide unconditional economic aid to under-developed territories had been made at a quite unrepresentative conference, couched in the most general terms, and was not mentioned in Russian reports.

Buying Machine Tools from Abroad

Particulars were asked for by Mr. F. G. Bowles (Labour) regarding the amount of sterling spent abroad by firms in this country on the purchase of machine tools. Many of these tools had to be bought from overseas when, to his knowledge, there were home industries, specially in the Midlands, which were able to supply them. In reply, Mr. J. K. Vaughan-Morgan, the Minister of State to the Board of Trade, said that United Kingdom imports, excluding imports of portable power tools, were valued at £21,800,000 in 1957. A separate figure for the amount of sterling paid in respect of these imports was not available. Britain, like other major countries, was still a very large net exporter of machine tools.

Management

MANAGING A SMALL FIRM

Small firms predominate in Britain and in their vast numbers play a special and important part in industrial organisation and growth. One often hears, in the best intentioned and by no means thoughtless quarters, that the days of the small firm are numbered, that the growing complexity of industrial life is too much for the simple, somewhat elemental, organisation patterns usually found in small industry. The promotion of free trade, whether in G.A.T.T., Common Market or Free Trade Area forms, is usually taken to mean a return to jungle law where survival is for the largest only. Yet there are small creatures in the jungle, many more than big ones, with their own way of competing for their needs. The proverbial interdependence of the lion and the ant is not without relevance to the present-day industrial pattern in this country. In other words the small firm has a part to play.

Papers on " Management Control of Small Engineering Firms," were presented to the Institution of Mechanical Engineers in London last week by three experts in management organisation, production engineering and financial control (members of the consulting firm, Urwick, Orr and Partners).

Arguments in Favour

One of the most powerful arguments in favour of small firms is that they exist and often prosper in most countries in approximately equal proportions. In Britain there are only 400 factories employing more than 2,000 people out of a total of 65,000 factories. Some 22,000 have payrolls varying between 25 and 100 employees and 16,000 between 11 and 25 employees. Half the industrial population is employed in these small factories. In American industry the proportions are not much less. In Europe the proportions are higher, and it is clear therefore that small units must at one time have filled a need; their steady increase (and a fairly high rate of new entrants) suggests that they still do. One distorting factor, applicable particularly to " free " or capitalist economies such as Britain and the United States, should be considered: the greatest opportunities are for the man who makes a start, builds up and sells. Capital formation, for nearly a century, has held and still holds the best hope of providing the means to a personal fortune. Thus tax anomalies are an incentive for the " bright boy " to start on his own; tax and financial controls the best insurance that he cannot do so easily. The two probably cancel out.

In the Netherlands there exists a foundation entitled " Training Courses and Research " which for some years now has been providing courses on small-scale industry. The parent body is the Netherlands Universities Foundation for International Co-operation (N.U.F.F.I.C.) at The Hague. The brochure on the course contains the following introductory paragraph which summarises international experience on the role of small firms:

" It is now generally recognised that there is a place for small industry in any industrial structure regardless of the stage of development of a country. With the widening of markets and improvement of transport conditions, large-scale industry in certain sectors may be more efficient than small-scale industry. On the other hand the diversification of demand accompanying economic progress will usually offer opportunities for the establishment of profitable small industries in other sectors. Thus the experience of most industrial countries seems proof that small-scale industry has a useful role to fulfil in any industrialisation programme. In many developing countries, which are often characterised by a scarcity of capital and a surplus of labour, the awareness of the contribution which a viable small-industry sector can make in raising living standards has been gaining ground in recent years."

Briefly the arguments in favour of small-scale industry are as follows: (1) small firms can hold their own and often have an advantage whenever possibilities for mechanisation are few and production is very labour-intensive; (2) when a product has to be made in many variations the possibilities for division of labour and the use of highly specialised machinery (one of the strongest points in favour of large-scale operations) become rather limited for a single enterprise; (3) no extensive transport network is required for the development of small firms; they tend to serve a smaller market, thus simplifying the distribution problem; (4) use can be made of labour (sometimes seasonal) available locally; (5) less technical skill is usually required, and managerial staff of the necessary calibre is more easily found, for the management task is essentially simpler; (6) the tools and equipment required are usually of a simple, general purpose type, can often be produced locally and represent a relatively small investment; (7) overhead costs (particularly administration and selling expenses) tend to be lower in relation to turnover than in the case of large-scale industry, and additional investment in overheads (power, buildings, housing, etc.) is low; and (8) small-scale industry is highly flexible and therefore readily adaptable to changes in demand and supply.

The above is a fair statement of the case for the small manufacturing unit. It does not preclude large units from enjoying similar advantages within their own structures. In fact, several of them, and at least one of the more recently formed groups, are made up of small firms whose considerable success had led to a serious shortage of capital so much more easily provided by a central organisation. In the present industrial and economic climate in Britain this may well prove to be the organisational pattern of the future for small-scale industry, preserving most of the advantages but facilitating co-operative efforts and providing the necessary finance.

Management Control

The first of the three papers presented was given by Mr. L. Fontaine under the heading " Building and Controlling a Management Team." Control is broadly defined as (1) indicating the lines along which the various activities of the business should be run; (2) developing mechanisms which help to ensure that the plans for each of the activities can be successfully carried out; (3) obtaining information at regular intervals, by means of accounting, statistical and other statements, about how the plans are progressing; and (4) taking such corrective action as the figures show to be necessary. This is rarely done in small firms. As Mr. Fontaine points out, most books on management consider only the problems of the medium and large business. Small firms in the engineering industry are currently having to cope with an increasing complexity of business which makes personal management using memory rather than records, and intuition (or " feel ") rather than deductive method, much more difficult and risky. There is also a tendency for profit margins to become narrower after the long years of easy selling. To-day, the difference between making a profit and making a loss is small enough to require finer measurements and a closer watch over the financial progress of the business.

Mr. Fontaine's paper deals with the various stages in the growth of a small engineering business from the start and concentrates on the tasks of the manager, often the owner of the firm. Much of it is necessarily general, such as the delegation of responsibilities (often a weakness in small firms); the need to avoid getting bogged down in detail and to divide policy from the executive task of carrying out the policy; the type of organisational pattern which takes the place of the simple " boss-worker " pattern of the old days of small businesses, and a clear statement of the basic principles of organisation. The owner-manager will find this latter section and the section on business relations which follows useful and provocative, as they touch upon subjects such as the separation and definition of duties, salary structures and incentives to good service, which are frequently neglected or dispensed with altogether. Among the questions of company policy which require a manager's decision are those relating to product policy—what should be the company's range of products?—to the planning of output in accordance with a forward sales budget, to sub-contracting and purchasing policy, to profitability and finance including investment policy. The owner-manager, argues Mr. Fontaine, must " realise that he is in charge of an intricate machine that is made up from human components and he must run it with a sure grip." He must watch, through the use of the data produced by management control techniques, that " all the parts are functioning according to the requirements of the overall plans and he must make adjustments as and when they become necessary."

Control of Production

The second and third papers were entitled " Control of Production Engineering " and " Control of Finance and Costs." The former, by Mr. J. W. Walker, enumerates the production problems the manager has to face and sketches out the techniques at his disposal. These fall under four broad headings: designing for economic manufacture, controlling the load on the factory, regulating the flow of orders through the factory, and improving productivity. The fundamental importance of sound design is stressed. The simplification of design, the questions of performance, appearance, price and rationalisation are too often neglected even by large firms. There is probably more scope in this field for economies and improvements than in any other.

The section of Mr. Walker's paper dealing with load control and with regulating the flow of orders through the factory is detailed and informative, obviously based on extensive knowledge and experience of the problems involved. Much of it turns on the need to plan and to produce the basic information required for making, executing and adjusting the plans. The final section on productivity analyses the functions of work study, the study of manufacturing method and the use of incentives. Again, this is practical, down-to-earth advice but by now fairly familiar.

Control of Finance

Mr. W. R. Spencer's paper on " Control of Finance and Costs " is emphatic in recommending the employment of a qualified accountant, " a prerequisite for obtaining adequate managerial control over finance and costs, even in a small business." Mr. Spencer gives advice on bookkeeping methods, on uses and dangers of accounting machinery (" should not be introduced merely because of enthusiasm for mechanisation "), and on the use of standards against which performance can be evaluated. The control of the cash situation, and of costs (labour, materials and overheads) and the functions of a " proper system " of cost finding in order to establish reliably the cost of each product, are explained and the methods indicated by which these functions can be satisfactorily discharged.

To have a comprehensive picture of management problems in a small firm, particularly when it is based on the specialised experience of experts with a broad as well as detailed knowledge of industry, is most valuable.

Continuing **Management**

TRAINING THE STEELMEN

It is the responsibility of the Iron and Steel Board, according to the 1953 Act, to take steps to promote the training and education of persons employed in the industry, if existing arrangements appear to be inadequate. This continues the duty laid on the nationalised Iron and Steel Corporation, but no mention is made in their last annual report of any action by the Board on this matter. This is no doubt because of the extensive arrangements made to-day by individual firms in the industry with the help and advice of the Committee set up in 1948 for that purpose by the British Iron and Steel Federation.

The Federation has now prepared a *Survey of Training in the Iron and Steel Industry*, which gives a good idea of the wide range of facilities now available for training of every kind. The industry suffered, as most other traditional industries have suffered, from problems arising from the wide range in size of its individual companies and the great variety of their products. There is also no doubt that there were special problems arising out of the conflict between new technological advances, such as instrumentation and automatic control, and the established pattern of working groups and the status of particular operatives within them. The survey draws attention to some of the difficulties that had to be faced when planning the training of operatives who form about half of all the workers in the industry under the age of 21. One of the difficulties is the fact that production processes are carried out by teams of men working on shifts and promotion is normally by seniority.

These difficulties have to some extent been overcome by giving the newcomer introductory courses about the structure, processes and products of the company and, if he enters at the age of 15, a year's general training with experience in a number of different departments. In addition to practical training in the works, many companies are encouraging their employees to take the iron and steel operatives' course of the City and Guilds of London Institute which was started shortly before the war. Sometimes these courses are held in the works so that workers on shift can attend. During the last three years between 1,200 and 1,300 people have taken this examination.

Firms in the industry provide every sort of opportunity for training not only for operatives, but also for craftsmen, technical staff, foremen and managers, and commercial and clerical staff. The attitude towards technical staff appears rather conservative. No reference is made to the training of university graduates, although more and more use is being made of sandwich courses, and it is expected that many of these will, in the future, be for the Diploma in Technology. There does not seem to be any distinction drawn between the professional engineer and the technician; training for "technical" or "student" apprentices generally leading to a Higher National Certificate as the first stage towards obtaining higher qualifications. Most companies, however, encourage suitable apprentices to qualify for university training and some award scholarships or grants for this purpose. The practice of companies no doubt varies greatly; for certainly some of them have education and training departments as progressive as those in any industry.

Apart from the arrangements made for foremen training by individual companies, some of them residential, courses are arranged by the area training committees of the Federation. These usually last for five days and consist of talks and discussions on a number of subjects relating to the foreman's job such as industrial organisation, costing, industrial law and man management. During the last six years over 2,350 foremen from 150 companies have attended such courses. A more recent development has been the holding of specialist courses for foremen from similar departments in different companies.

The industry appears to be well aware of the problem of ensuring an adequate supply of competent managers arising out of the growing technological complexity of the industry as well as recent educational developments, which are forcing industry to look more and more to the grammar and public schools and the universities for its managerial recruits. Almost all the large companies have established formal management training schemes. There is also an exchange scheme organised by the Federation through which over 80 young executives are sent abroad every year for a month's visit to Europe.

Residential courses for potential managers are now run on a national basis to supplement the courses run by two or three of the largest companies. At these courses a large proportion of the time is spent on syndicate work; but in addition the syllabus includes formal talks, case study work and visits to works to investigate special problems. The composition of the students is arranged so as to provide a balanced representation of the departments in a works.

In each of the eight steel-making districts the Federation has established an area training committee, with officers in the six largest. In London the headquarters of the Federation's training department act as a clearing house for information as well as arranging courses and conferences for the industry as a whole. Co-operative training courses are arranged for the smaller companies or for certain specialised subjects. To assist in training a wide range of publications and visual aids, in the form of films, filmstrips and wall charts, has been produced by the training committee. Most of these have been designed to cover the syllabus of the iron and steel operatives' course. A small magazine is published quarterly containing information on recent training developments as well as giving special memoranda from time to time.

The training committee has also been active in arranging conferences. Every year since 1948 an annual conference has been held at Ashorne Hill, Warwickshire, at which some aspects of training in the industry have been discussed. A recent development has been the holding of shorter conferences lasting a day and a half on some specialised aspect of a training officer's work. Special courses are also run for training officers in the industry. A more detailed account of management training is shortly to be issued.

WORLD VIEW OF A DEFICIT

Scarcity of Engineers and Scientists Reviewed

It is sometimes overlooked that the shortage of engineers and scientists—so familiar in Britain—is in fact on a world scale. The shortage is a manifestation not so much of inadequate foresight but of the lag in readjustment to a new world situation. The solution of Britain's problem may be assisted by a study of the shortage as it affects the world in general, and the December issue of the *International Labour Review*, the journal of the International Labour Office, brings together in a single article a great deal of material from government publications, committees of inquiry, independent research studies and elsewhere.

1. How Big a Shortage?

The article states that the percentage of graduate engineers and scientists in proportion to the labour force is highest in the United States and Canada, followed by Switzerland, Norway, and Great Britain. But while the proportion varies between 0·31 per cent. and 1·36 per cent. in these countries, it reaches 1·7 per cent. of the non-agricultural labour force in the U.S.S.R. or 0·9 per cent. of the total labour force. For Britain an annual output of qualified scientists and engineers of 16,900 in 1966 and 19,900 in 1970 is required compared with the 10,300 actually produced in 1955. But the situation is not noticeably better in other countries. An estimate quoted for France shows an annual deficit of 22,000 engineers and the position is expected to get worse until measures recently taken begin to have an effect in about 1963. In the United States an annual output of 43,000 engineering graduates will be required in 1964 as against 22,200 in 1954.

The article explains that contradictory views are held in Federal Germany on future requirements of engineering graduates. Some wish to see the total capacity of technical universities for electrical and mechanical engineering doubled in the near future, while others believe that present capacity is sufficient and that there is no need to increase the number of university places. The sixth five-year plan in the U.S.S.R., which began in 1956, provides for a 50 per cent. increase in the number of specialists and "roughly double" the number of graduates for heavy industry, construction, transport and agriculture.

There appears to be general agreement that the present shortage of scientific and technical personnel is not due to temporary fluctuation of demand in the countries concerned. Rather it is a stage in the evolution of their social and economic structures which is accompanied by rapid technological development.

2. Increasing the Supply

The article in the *International Labour Review* emphasises that the shortage of engineers and scientists can only be cured by taking action on two factors influencing the supply. These are securing the interest of young people at an early age and secondly overcoming the chronic shortage of qualified science teachers. The need to stimulate interest at an early age is generally recognised. Early specialisation is not popular, however, and has been particularly criticised in France. Shortage of science courses is cited as a serious factor in the United States where many schools provide none at all. In Britain extra curricula activities such as the Schoolboy's Exhibition play an important part in this "catch-them-young" movement. The shortage of science teachers is particularly serious in the United States. The general shortage of high-school teachers affects the quality of all teaching. From 250,000 to 400,000 high-school students in the United States are at present learning mathematics and science from teachers not trained to teach these subjects. The National Science Foundation has sponsored summer courses and provided grants for a full year's course for American high-school science teachers.

The Public Employment Service has introduced aptitude tests for discovering latent ability in students in their last year. In Switzerland special inducements are given to tempt more young people to study nuclear physics. In France the Ministry of Education has sent out a circular stressing the urgent need to direct larger numbers of pupils into scientific studies. Steps are also being taken in various countries to raise the prestige of scientific and engineering posts as compared with commercial and administrative ones. Women are regarded as an important reserve of scientific and technical skill and recent studies in the United States lay stress on the employment possibilities of married women.

Marketing

AMERICA'S PROBLEM

Typical of Americans' competitive approach to life was the holding of an open competition for ideas on " the most important problem to be faced by the United States in the next 20 years." The occasion was the 15th anniversary of the Committee for Economic Development, which is a research and educational organisation supported by business concerns. No definite, classifiable, answer was obtained but underlying most of the contributions was a feeling that the United States must find new ways of competing in a changed world. Most contributors foresaw a gradual shift from the emphasis on armaments of the past ten years to one on economic and social factors during the next decade of competition between the rival and inherently hostile political systems of East and West. In the words of Paul Prebisch of the United Nations, " Capitalism has not yet been fully able to meet the Communist challenge " which has taken the form of an appeal to the rising generations to strive for economic improvement with Soviet help. In Prebish's view, " the task of fitting capitalism to meet this challenge in the underdeveloped countries is the most important economic problem to be faced by the United States."

In practical terms, the economists concerned themselves with the effect of the switch from armaments to investment. They considered it could and would probably be an acute transitional problem severely testing America's economic strength. The solutions suggested were major increases in consumption and investment both at home and abroad. The feeling that economic problems were increasingly problems of government was fairly general. Non-military Government activity would become the king-pin of economic stability: at home it meant very substantial participation in the development of natural resources and abroad a similar contribution to the creation of basic services in poor countries. It was pointed out that at least 80 per cent. of the capital they need cannot be contributed by private investors for it is essentially needed for roads, railways and ports, electricity and water supplies, housing and health services. The return on such an investment may be nil for many years and was essentially a government's function.

The United States Government's decision to lend India 225 million dols. (about £80 million) and to help to alleviate that country's grain shortage, may prove to be the beginning of large-scale assistance without strings attached. Mr. Dulles said that the United States would do " what it could " to support the Indian five-year plan, and expressed the hope that other countries (West Germany for instance) would participate. The Americans' difficulty will be the reluctance of Congress to sanction loans that do not place conditions upon the granting of aid. But gradually the conviction is growing that " aid " is not the right word. Investment in India's economic future and in that of other Far Eastern and African countries, is the most effective answer to Russia's challenge. What *The Times* recently called " Aid without Odium;" how to give it and to give enough of it, is the great problem of the next 10 years for the U.S.

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I.C.I. in India

A recent statement by Sir Alexander Fleck, chairman of Imperial Chemical Industries, indicated that the company have substantial investments in India and intend to increase them. They are at present engaged in putting up new chemical plants for separate companies in partnership with Indian capital. When completed, these will have added £9 million to the total investment in the Indian chemical industry in private business. Further schemes under discussion may raise this total to £12 million.

Dr. Fleck said that he saw the possibilities of a " bigger and better dyestuffs industry " in India, and that I.C.I. would like to offer Indian businessmen a " real and vital partnership " in developing it. The additional investments which have been decided will go to the chemical industry and take the form of three partnerships, with Atic Limited at Bulsar in the Bombay State, in the Alkali and Chemical Corporation of India at Rishra in West Bengal, and in a company set up jointly by I.C.I. and the Indian Government at Gomia in Bihar.

Other large British concerns making raw materials or capital plant will increasingly follow the same path. Considerable opportunities exist in the private sector of Indian industry, despite the fact that the Indian Government are committed to a Socialist policy with central planning and large-scale public investment. Dr. Fleck's conception of a " vital partnership " is the only workable formula in a country where national aspirations run high but opportunities abound.

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Prizes Well Won

The £1 million order obtained by Aveling-Barford in the Argentine is a hopeful sign that trade with that country may be re-opened. At the recent annual meeting of the company their chairman, Mr. E. Barford, complained bitterly of the hopeless inadequacy of credit facilities obtainable from the Export Credit Guarantee Department of the Board of Trade. No mention is made of credit terms in the announcement that 170 road-building 10-ton graders and spare parts will be supplied during the next year. The existence of " a highly efficient spares and service organisation " in the Argentine was stated to have been " one of the deciding factors " in Aveling-Barford's winning the contract. Another was " one of the keenest prices ever quoted " by them.

The quality and reputation of the equipment and the ability to maintain it are almost invariably the key factors in competition on the American continent. But credit plays a part in the south, as does the ability to execute barter deals. It would be interesting to hear more about the terms of the contract and the manner in which it was obtained.

Another success story was told by Burtonwood Engineering who have made considerable headway with the sale of oil seals in the United States. There, also, it was the ability to quote a competitive price " in spite of transport costs and tariff charges " and the setting up of a sales organisation which could offer " a delivery service to rival the American manufacturers'," that were the deciding factors in their progress.

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New Tool for Publicity

A new type of photo-projector has been developed by the Grant Production Company for the use of small firms who have offset-litho printing equipment but no means of reproducing illustrations. The equipment has been designed to produce good quality photo-litho plates for half-tone reproduction suitable for trade leaflets, house journals, and promotional material generally. It can be operated by an amateur photographer, but Grant arrange for the training of operators " to ensure that the machines are used to the fullest advantage."

The photo-projector has been designed for use with Kodak Magenta contact screens but can also be used with other similar equipment. Its simplicity and versatility will be an asset to the publicity manager and to others in a firm who require to have quick copies of any written or photographic material. It can be used for making continuous tone negatives and enlarged or reduced copies and, when fitted with a cold cathode lighting unit, it can be used as a photographic enlarger. This type of equipment is filling a widespread need for local printing which in recent years has led to a vast increase in the use of small offset-litho printing machines.

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Trade Fair Inquiry

At long last a full-scale investigation of existing exhibition facilities available in the United Kingdom will be carried out and the whole situation reviewed. The Grand Council of the Federation of British Industries have approved the appointment of a Committee of Inquiry whose terms of reference will be:

(1) To survey the adequacy of existing exhibition facilities throughout the United Kingdom in the light of the recent F.B.I. inquiry into the future trade-fair policy in this country and of the possible entry of the United Kingdom into a European Free Trade Area;

(2) to ascertain the extent to which the physical, technical and other requirements of exhibitors (including location and size of buildings and sites, availability of halls at time required, physical equipment, and amenities such as catering and hotel accommodation) are met, or are not met, by existing exhibition facilities; and

(3) to draw up and recommend plans for new or extended exhibition facilities, including estimates of cost and proposed location.

The Committee's chairman is Mr. George Pollitzer, the chairman of Beck and Pollitzer Limited, the exhibition organisers; the two members are Mr. R. W. Boardman, a director of F. W. Bridges, exhibition contractors, and Mr. W. Marrable, head of the Exhibitions Department of I.C.I. They will seek interviews with trade associations which sponsor trade fairs and will also " welcome evidence from others interested." It was the comment of several important trade associations on " the serious lack of proper exhibition facilities in this country " which prompted this inquiry.

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A New House Journal

Constructors John Brown Limited, formerly Costain-John Brown, have produced the first issue of their house journal with a question mark instead of a title. Readers are invited to suggest a title with the statement " What shall we call ourselves? It's for you to decide."

This is an interesting way to arouse interest. The company's chairman, Sir Stanley Rawson, writes in a foreword that the journal is intended to be " a symbol of unity by which members of our staff are bound together," and that it is " only by unity of interest and sympathy that we can create the groups which enable us to accomplish the many difficult undertakings which bear our name." To C.J.B., as to most other large contractors, a unifying symbol is of great importance, for their staff is necessarily dispersed all over the world. The journal will report on the progress of various schemes in various countries and give news of developments at home. In their first issue there is a short description of the company's new Research and Development Station at Leatherhead, and a note on the erection of the 16 heat exchangers—each weighing 178 tons and 80 ft. high—at Calder Hall. There are notes on new products and processes, progress in schemes, a " profile " on Sir Harold Hartley and two pages of staff news.

The name of the new journal is something for C.J.B. staff to suggest. To the firm's suppliers and customers it will be a welcome commentary on the affairs of a powerful group.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, *November* 29, *page* 683, *and December* 27, *page* 812. *Organisers are invited to send particulars of coming events to the Editor.*

Progress and Trends in Chemical and Petroleum Instrumentation, National Conference.—Mon., and Tues., Feb. 3 and 4, at Wilmington, Delaware, U.S.A. Organised by the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

Canadian Institute of Surveying and Photogrammetry, Annual Meeting.—Wed., Feb. 5, to Fri., Feb. 7, at Ottawa. Organised by the Institute, P.O. Box 57, Westboro, Ontario, Canada.

Developments in Foundry Technology, Symposium.—Wed., Feb. 5, to Sat Feb. 8, at Jamshedpur. Organised by the National Metallurgical Laboratory, Council of Scientific and Industrial Research, Jamshedpur 7, India.

***Work Study Conference.**—Thurs., Feb. 6, at Caxton Hall, off Victoria-street, London, S.W.1. Organised by the British Institute of Management, 80 Fetter-lane, London, E.C.4. Tel. HOLborn 3456.

Non-Destructive Testing of Materials, Course on.—Sun., Feb. 9, to Sat., Feb. 22, in London and the provinces. Fee £42. Organised by the British Council, 65 Davies-street, London, W.1 (Tel. GROsvenor 8011), for people from overseas.

Canadian Hardware Show, 53rd Annual.—Mon., Feb. 10, to Thurs., Feb. 13, in the Canadian National Exhibition Grounds, Toronto. Organised by the Canadian Retail Hardware Association, 290 Merton-street, Toronto 7, Ontario, Canada.

National Stationery and Book Trades Fair.—Mon., Feb. 10, to Fri., Feb. 14, in the Royal Horticultural Society's Old Hall in Vincent-square, and New Hall in Greycoat-street, London, S.W.1. Organised by National Newsagent (Exhibitions), Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

Power Farming Conference, National.—Tues., Feb. 11, to Thurs., Feb. 13, at the Town Hall, Cheltenham, Glos. Organised by the *Practical Power Farmer*, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

Motor Show, International.—Thurs., Feb. 13, to Sun., Feb. 23, at Amsterdam. Organised by the Nederlands Association of the Cycle and Automobile Industry, De Lairessestraat 13, Amsterdam Z, Holland.

National Salon of Agriculture, Sixth.—Thurs., Feb. 13, to Sun., Feb. 23, at the Show Mart, Montreal. Agricultural machinery exhibits. Organised by the Salon National de l'Agriculture, 152 Notre Dame-street East, Montreal.

British Toy Fair, Fifth.—Mon., Feb. 17, to Sat., Feb. 22, at Brighton. Organised by the British Toy Manufacturers' Association, 94 Hatton-garden, London, E.C.1. Tel. CHAncery 9158.

MACHINE TOOLS

***Machine Tools Exhibition.**—Mon., Feb. 17, to Sat., Feb. 22, in the Princes Hall, Bingley Hall, Broad-street, Birmingham. Showing the firm's complete range of equipment, including new products. Organised by B. Elliott and Co., Ltd., Victoria-road, Willesden, London, N.W.10. Tel. ELGar 4050.

***Photographic Show, 12th Annual.**—Mon., Feb. 17, to Sun., Feb. 23, at the New York Coliseum, New York. Organised by the Photographic Manufacturers and Distributors Association, Inc., Suite 704, 350 Lexington-avenue, New York 16, U.S.A.

Scottish Dairy Show.—Tues., Feb. 18, to Fri., Feb. 21, at Kelvin Hall, Glasgow. Apply to the general manager, Dairy Show, Corporation of Glasgow, Kelvin Hall, Glasgow, C.3.

Chesapeake Bay Boat Show.—Fri., Feb. 21, to Wed., Feb. 26, at the 5th Regiment Armoury, Baltimore. Offices of the Show: 1006 Cathedral-street, Baltimore 1, Maryland, U.S.A.

Miami International Boat Show, 17th Annual.—Fri., Feb. 21, to Wed., Feb. 26, at Miami. Offices of the Show: 615 S.W. 2nd-avenue, Miami 36, Florida, U.S.A.

"Detroit News" Boat Show.—Sat., Feb. 22, to Sun., Mar. 2, in Detroit. Organised by the Detroit Boat Show, Inc., 16733E Warren-avenue, Detroit 24, Michigan, U.S.A.

Nice International Fair.—Sat., Feb. 22, to Mon., Mar. 10, at Nice. Organised by the Foire Internationale de Nice, 8 Place Massena, Nice.

Hardware Trades Fair, Fourth.—Mon., Feb. 24, to Fri., Feb. 28, in the Royal Horticultural Society's Old Hall, Vincent-square, and New Hall, Greycoat-street, London, S.W.1; also in the Central Hall, Westminster, London, S.W.1. Organised by Universal Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7723.

***Display Market Week.**—Mon., Feb. 24, to Sat., Mar. 1, at the Waldorf Hotel, Aldwych, London, W.C.2. Organised by the National Display Equipment Association, 9 Victoria-street, S.W.1. Tel. ABBey 4813.

***Metallurgical Aspects of Semi-Conductors.**—Tues., Feb. 25, at the College of Technology, Gosta Green, Birmingham. An exhibition is being arranged at the College, in conjunction with the meeting, by the Royal Radar Establishment, Great Malvern. This will open on Feb. 25, and on the evening of Feb. 24. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Fuel Efficiency in the Metal Industries. All-Day Discussion.—Wed., Feb. 26, at the College of Technology, Gosta Green, Birmingham. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

***Making the Pound Go Further: The Task of Operational Research in Industry.**—Thurs., Feb. 27, at the Imperial Hotel, Russell-square, London, W.C.1. One-day conference (fee £5) organised by the British Institute of Management, 80 Fetter-lane, London, E.C.4 (Tel. HOLborn 3456), in conjunction with the Operational Research Society, 2 Grosvenor-place, London, S.W.1. Tel. SLOane 3401.

Recent Advances in Polymer Technology, Conference.—Thurs., Feb. 27, probably at Institution of Civil Engineers, Great George-street, London, S.W.1. Organised jointly by the Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8 (Tel. BAYswater 9101); and the Plastics Institute, 6 Mandeville-place, London, W.1. Tel. WELbeck 5439.

***New Building Materials and Techniques Exhibition.**—Fri., Feb. 28, and Sat., Mar. 1, at the Royal York Hotel, Toronto. Organised by the Ontario Association of Architects, 50 Park-road, Toronto.

COLOGNE FAIR

Cologne International Spring Trade Fair.—*Household Goods and Hardware:* Fri., Feb. 28, to Mon., Mar. 3; and *Textiles and Clothing:* Sun., Mar. 9, to Tues., Mar. 11, in Cologne. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

***Leipzig Spring Fair.**—Sun., Mar. 2, to Tues., Mar. 11, at Leipzig. *Agents:* Leipzig Fair Agency, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

***Smallwares Trade Fair, Fifth.**—Mon., Mar. 3, to Fri., Mar. 7, at the Metropole Hotel, Brighton. Organised by Trade and Technical Exhibitions Ltd., 1 Dorset Buildings, Salisbury-square, London, E.C.4. Tel. FLEet Street 1555.

***Scientific and Technical Translation, Conference.**—Wed., Mar. 5, at the Connaught Rooms, Great Queen-street, London, W.C.2. Organised by Aslib, 4 Palace-gate, London, W.8. Tel. KNIghtsbridge 0444.

***Australian Industries Fair, Second.**—Fri., Mar. 7, to Sat., Mar. 29, in the Exhibition Building, Melbourne. Organised by the Victorian Chamber of Manufactures, 312 Flinders-street, Melbourne, C.1.

***Toy and Trades Fair, International.**—Sun., Mar. 9, to Fri., Mar. 14, at the Statler Hotel, New York. Organised by International Trade Shows, 545 Fifth-avenue, New York 17, U.S.A.

***Canadian Restaurant Association: Annual Convention and Exposition.**—Mon., Mar. 24, to Thurs., Mar. 27, at the Automotive Building, Toronto. Food machinery and equipment. Organised by the Canadian Restaurant Association, 415 Bloor-street West, Toronto, Ontario.

***Radio Engineering Show.**—Mon., Mar. 24, to Thurs., Mar. 27, at the New York Coliseum, New York. Sponsored by the Institute of Radio Engineers. Organised by William C. Copp Associates, 72 West 45th-street, New York 22, U.S.A.

***Rand Easter Show, 48th.**—Tues., Mar. 25, to Mon., April 7, at Johannesburg. Agricultural machinery and dairy implements. Organised by the Witwatersrand Agricultural Society, Show Grounds, Milner Park, Johannesburg, South Africa.

***British Mathematical Colloquium.**—Wed., Mar. 26, to Fri., Mar. 28, at The University, Reading. Organising secretary: Mr. J. E. Reeve, Department of Mathematics, The University, Whiteknights Park, Reading. Tel. Reading 82481. Applications should be submitted as promptly as possible. Accommodation will be available at university halls.

***Automobile Show, International.**—Sat., April 5, to Sun., April 13, at New York Coliseum, New York. Organised by the Charles Snitow Organisation, 331 Madison-avenue, New York 17, U.S.A.

***Design Engineering Show, Third.**—Mon., April 14, to Thurs., April 17, at the International Amphitheater, Chicago. Organisers: Clapp and Poliak, Inc., 341 Madison-avenue, New York 17, U.S.A.

***Industrial Textiles Fair, Third.**—Mon., April 14, to Fri., April 18, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell-street, London, W.C.2. Tel. TEMple Bar 3422.

***Audio Fair.**—Fri., April 18, to Mon., April 21, at the Waldorf Hotel, Aldwych, London, W.C.2. Organised by Audio Fairs Ltd., 42 Manchester-street, London, W.1. Tel. WELbeck 9111.

***Packaging and Profit, Conference.**—Thurs., April 24, to Sat., April 26, at the Grand Hotel, Eastbourne. Organised by the Institute of Packaging, 20-21 Took's-court, Cursitor-street, London, E.C.4. Tel. CHAncery 8484.

***Casablanca International Trade Fair, 13th.**—Fri., April 25, to Sun., May 11, at Casablanca. Fair offices: Rue Jules Mauran, Casablanca.

***Health Exhibition.**—Mon., April 28, to Fri., May 2, at Eastbourne. Organised by the Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. Tel. SLOane 5134.

***German Handicrafts and Trade Fair, 10th.**—Thurs., May 15, to Mon., May 26, at Munich. *Offices:* Theresienhöhe 14, Munich 12, Germany. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

***Automotive International Technical Congress, Seventh.**—Mon., May 19, to Wed., May 28, in Paris. Organised by the Société des Ingénieurs de l'Automobile, 5 Avenue de Friedland, Paris 8e.

***American National Office Machinery Association: 39th Annual Exposition.**—Mon., May 26, to Thurs., May 29, at the Conrad Hilton Hotel, Chicago. Associaton offices: Willow Grove, Pennsylvania, U.S.A.

***Packaging Exposition, 27th National.**—Mon., May 26, to Fri., May 30, at the New York Coliseum, New York. Organised by Clapp and Poliak, Inc., 341 Madison-avenue, New York 17, U.S.A.

***Thermal and Hydraulic Power Stations, Conference.**—Tues., May 27, to Sat., May 31, at the Palais des Congrès, Liége. Subjects to cover boilers, steam turbines, hydraulic turbines and alternators. Organised by the Association des Ingénieurs Electriciens sortis de l'Institut Electrotechnique Montefiore, 31 Rue Saint-Gilles, Liége, Belgium.

MONTREAL TRADE FAIR

***Montreal International Trade Fair.**—Fri., May 30, to Sun., June 8, in the Show Mart, Montreal. Fair offices: Suites 227-228, 1600 Berri-street, Montreal, Canada.

***Padua International Fair and Packaging Salon.**—Sat., May 31, to Sun., June 15, at Padua, North Italy. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 4951.

***Gas Turbines, Conference.**—Wed., June 4, to Fri., June 6, at the hall of the Faculté Polytechnique, Boulevard Dolez, Mons. Organised by the Faculté Polytechnique de Mons, 9 Rue de Houdain, Mons, Belgium.

***Israel Tenth Anniversary Exhibition.**—Thurs., June 5, to Thurs., Aug. 21, at the Binyaney Hacoma, Jerusalem. Organised by the Tenth Anniversary Exhibition Co., P.O.B. 6001, Jerusalem, Israel.

***Canadian National Business Show.**—Mon., June 9, to Wed., June 11, in the Automotive Building, Toronto. Show offices: 745 Mount Pleasant-road, Toronto, Canada.

***British Electrical Power Convention.**—Mon., June 16, to Fri., June 20, at Brighton. Theme: "Electricity and World Progress—Britain's Contribution." Organised by the British Electrical Power Convention, Eastcastle-street, London, W.1. (Tel. MUSeum 4040.) An exhibition of electrical apparatus will be held in Brighton during the same period. Organisers: The British Electrical Development Association, 2 Savoy-hill, London, W.C.2. Tel. TEMple Bar 9434. (Additional information.)

***Electronics and Nuclear Energy, Fifth International Congress and Exhibition.**—Mon., June 16, to Mon., June 30, at Rome. Organised by the Rassegna Internazionale Electtronica e Nucleare, 14 Via della Scrofa, Rome. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 4951. (Alteration of dates.)

***Civil Engineering Problems Overseas, Conference on.**—Week commencing Mon., June 23, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Open, in certain cases, to non-members. Apply to the secretary of the Institution, at the above address. Tel. WHItehall 4577.

***Office Machine Dealers' Association, National Exhibition.**—Sun., June 29, to Wed., July 2, at the Schroeder Hotel, Milwaukee. Association offices: 1542 Hillhurst-avenue, Los Angeles 27, Cal., U.S.A.

***Institution of Naval Architects, Summer Meeting in Paris.**—Mon., June 30, to Fri., July 4. Organised by the Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. Tel. SLOane 4622.

Royal Show.—Tues., July 1, to Fri., July 4, in Bristol. Organised by the Royal Agricultural Society of England, 35 Belgrave-square, London, S.W.1. Tel. BELgravia 5323.

***Sydney Engineering Exhibition.**—Mon., July 14, to Sat., July 19, at the Royal Agricultural Showgrounds, Moore Park, Sydney. Apply to the Industrial Public Relations Service of Australia, Box 4962, G.P.O., Sydney, Australia.

***Victoria State Fair.**—Mon., July 21, to Sat., Aug. 2, at the Exhibition Buildings, Melbourne. Organised by the Industrial Public Relations Service of Australia, 82 W. Toorak-road, South Yarra, Victoria.

***Eastern Province Agricultural and Trade Show.**—In August, at Morogoro, Tanganyika. Organised by the Arusha Chamber of Commerce and Agriculture, P.O. Box 141, Arusha, Tanganyika.

***Western Electronic Show and Convention.**—Tues., Aug. 19, to Fri., Aug. 22, at the Pan Pacific Auditorium, Los Angeles. Organised by Wescon, 342 North La Brea-avenue, Los Angeles, Cal., U.S.A.

***British Radio and Television Exhibition, 25th.**—Wed., Aug. 27, to Sat., Sept. 6, at Earl's Court, London, S.W.5. Organised by the Radio Industries Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

***Surabaya International Fair.**—Fri., Aug. 29, to Sun., Oct. 5, at Surabaya, Indonesia. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 4951.

***Leipzig International Autumn Fair.**—Sun., Sept. 7, to Sun., Sept. 14, at Leipzig. *Agents:* Leipzig Fair Agency, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

***Place of the University in the Education of Civil Engineers, Conference.**—Tues., Sept. 9, to Fri., Sept. 12, at the Queen's University of Belfast. Open to civil engineering delegates from industry and the universities. Apply to the organising secretary, David Keir Building, Stranmillis-road, Belfast.

***Chemical Exposition, National.**—Tues., Sept. 9, to Fri., Sept. 12, at the International Amphitheater, Chicago. Organised by the Chicago Section, American Chemical Society, 86 East Randolph-street, Chicago, Ill., U.S.A.

***Instrument Automation Conference and Exhibit, 13th Annual.**—Mon., Sept. 15, to Fri., Sept. 19, in Philadelphia. Organised by the Instrument Society of America, 3443 South Hill-street, Los Angeles 17, Cal., U.S.A.

Electrochemical Society Inc., Conference.—Sun., Sept. 28, to Thurs., Oct. 2, at Ottawa. Offices of the Society: 216 West 102nd-street, New York 25.

***Baghdad Agricultural and Trade Fair.**—In October, at Baghdad. Apply to the office of the Mutassarif of Baghdad Liwa, Baghdad, 'Iraq.

***Kenya Royal Show.**—Wed., Oct. 1, to Sat., Oct. 4, in Nairobi. Organised by the Royal Agricultural Society of Kenya, P.O. Box 30176, Nairobi, Kenya.

STRUCTURAL ENGINEERING

Future of Structural Engineering.—Tues., Oct. 7, to Fri., Oct. 10. Fiftieth Anniversary conference of the Institution of Structural Engineers, to be held at its headquarters, 11 Upper Belgrave-street, London, S.W.1. Tel. SLOane 7128.

***Building Trades Exhibition.**—Tues., Oct. 14, to Sat., Oct. 25, in the City Hall, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

***Engineering Industries Association: 11th London Regional Display.**—Tues., Oct. 21, to Thurs., Oct. 23, at the Royal Horticultural Society's New Hall, Greycoat-street, and Old Hall, Vincent-square, London, S.W.1. Offices of the Association: 9 Seymour-street, London, W.1. Tel. WELbeck 2241.

***Motor Show, 43rd International.**—Wed., Oct. 22, to Sat., Nov. 1, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Automatic Merchandising Convention and Exhibition, National.**—Sun., Nov. 2, to Wed., Nov. 5, at Kiel Auditorium, St. Louis. Offices: 7 S. Dearborn-street, Chicago, Ill., U.S.A.

***Scientific Instrument Manufacturers' Association of Great Britain (SIMA), Convention.**—Thurs., Nov. 6, to Sun., Nov. 9, at the Majestic Hotel, Harrogate. Association's offices: 20 Queen Anne-street, London, W.1. Tel. LANgham 4251.

***Cycle and Motor Cycle Show.**—Sat., Nov. 15, to Sat., Nov. 22, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Industries Association, Ltd., The Towers, Warwick-road, Coventry. Tel. Coventry 62511.

***Smithfield Show and Agricultural Machinery Exhibition.**—Mon., Dec. 8, to Fri., Dec. 12, at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Co-ordination Chemistry, International Conference on.**—Mon., April 6, to Sat., April 11, 1959, in London. Sponsored by the International Union of Pure and Applied Chemistry. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

***World Petroleum Congress, Fifth.**—Early in June 1959, at New York Coliseum, New York, U.S.A. Apply to the British National Committee, Institute of Petroleum, 16 New Cavendish-street, London, W.1. Tel. LANgham 2250. (Change of Institution address.)

Metals and Materials

DIFFERENTIAL ANNEALING OF ALUMINIUM

Strengthens Deep-Drawn Containers

Deep-drawn aluminium products, stronger and in some cases cheaper than those previously available, may now be produced by using sheet material that has been prepared by a process known as differential annealing. This process, now in operation at the Rogerstone Works, South Wales, of the Northern Aluminium Company, Limited, controls the temper distribution across a blank sheet in such a manner as to make greater cupping reductions possible, and at the same time to give a stronger product than can be obtained using a uniformly-annealed blank.

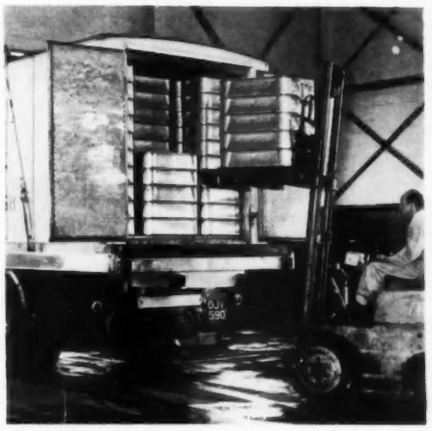
Differential annealing was developed following large-scale laboratory investigations into the problems of the reduction of blanks by deep-drawing. It is well known that the base of a deep-drawn container made from a soft blank sheet remains essentially soft, while the strength and hardness of the walls increase gradually from the base to the top rim due to the work-hardening of the metal in the drawing operation. It has been established experimentally that, by taking an initially hard blank and annealing the rim only, the stronger base makes it possible to obtain far greater cupping reductions.

Differential annealing is based on these principles and by annealing a blank so that the distribution of retained hardness is inversely proportional to the distribution of the work-hardening pattern obtained in cupping, a container of uniform hardness, namely, that of the material in the heavily work-hardened condition, is obtained.

The technique, at present, is being used mainly in the quantity production of large rectangular blanks, over 40 in. square, for making fish-handling boxes. These boxes, which are seen in the accompanying illustration are much more robust than those previously used and are better able to withstand the heavy handling received in the fish landing and loading bays.

The technique, at present, is suitable for shaped blanks or circles having a minimum diagonal length or diameter of 15 in. and a maximum length or diameter of 54 in. It is anticipated, however, that, in time, a larger range of sizes may be dealt with.

It is pointed out, in conclusion, that differentially-annealed blanks can be used also for spinning and, as with deep-drawing, making stronger products. The techniques were fully discussed in ENGINEERING, vol. 181, page 48.



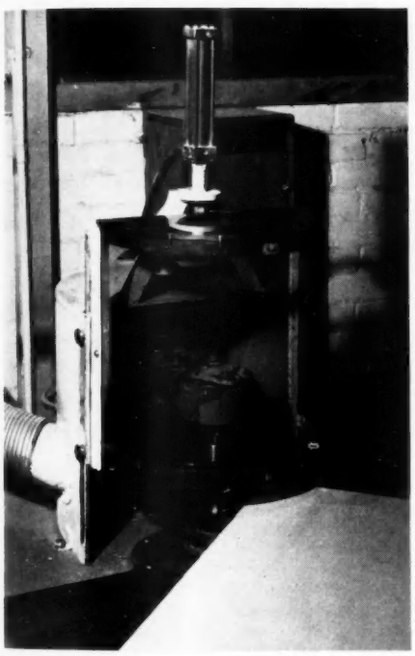
Rectangular aluminium fish boxes, made from differentially-annealed material, being loaded for transport by road. The annealing treatment produces a robust container of uniform hardness.

TRANSPARENT MACHINE GUARDS

A semi-rigid transparent sheet for use in making machine guards, protective screens and windows, has been introduced by Bakelite Limited, 12-18 Grosvenor-gardens, London, S.W.1. The new material, known as Vyback DVB 229, is based on polyvinyl chloride resin and it is stated to be non-inflammable and resistant to water, chemicals and oils. Other important properties are that it has high resilience and will withstand considerable mechanical abuse without shattering. It is available in standard sizes measuring 50 in. by 26 in. and 50 in. by 40 in., and either $\frac{1}{8}$ in. or $\frac{1}{4}$ in. thick, with both surfaces highly polished.

The new material can be easily fabricated by the usual methods, namely, sawing and drilling, and it can be assembled by conventional means, with or without a frame. As the material is semi-rigid the sheet can tolerate a slight curvature on fitting, although, naturally, care should be taken to avoid excessive strain. When a curvature or radius is required, the material can be formed by warming the $\frac{1}{8}$ in. thick sheet for 10 minutes at a temperature between 105 deg. and 110 deg. C., and the $\frac{1}{4}$ in. thick sheet for 10 minutes between 110 deg. and 115 deg. C.

The accompanying illustration shows an automatic spindle moulding machine equipped with a pneumatically-operated guard fabricated from the $\frac{1}{4}$ in. thick material.



Transparent P.V.C. sheet used for making machine guards shown in position on a moulding machine. The sheet is semi-rigid and will withstand considerable abuse without shattering.

FIRE-RESISTANT FLUIDS FOR HYDRAULIC SYSTEMS

The petroleum oil normally employed as the fluid in a hydraulic system is commonly recognised as an inflammable material, and should it spray out from a broken hose pipe or faulty connection or drip from a leaky seal on to a source of ignition, a fire almost inevitably will result. The seriousness of the fire, of course, would depend on the quantity of oil leaking out and also on the combustible nature of the material present. This might comprise clothing, wood floors or ceiling beams, cardboard containers or wooden boxes, rags, waste, open oil drums and solvents. Industry, fire-insurance organisations and oil supplying companies have worked together to reduce the fire hazards which exist where hydraulic machines operate near a possible source of ignition. Thus machines have been redesigned and greater attention paid to their position in the laboratory or workshop; means have been adopted to improve the control of any leakage from a hydraulic system and fire-control equipment has been installed.

Possibly the most favourable solution has been the development of fire-resisting hydraulic fluids. Their use is particularly desirable in such plants as die-casting machines, pressure-welding machines, presses and other machines situated near fuel-fired furnaces, glass-drawing machinery in which contact with molten glass is possible, scrap-baling presses having open heaters employed nearby, and machines or mechanisms adjacent to red-hot or molten metal, such as furnace-door openers, combustion regulators and ladle-tilting mechanisms.

For use in these and similar applications the Mobil Oil Company, Limited, Caxton House, Westminster, London, S.W.1, have developed two water-base fire-resistant fluids which, they state, will meet the requirements of most hydraulic systems. The fluids are called Mobil Nyvac Nos. 20 and 30 and are described as mixtures of water and several different ingredients and additives each serving a specific function. Tests have shown the fluids to combine a high degree of fire resistance with characteristics desirable in liquids developed for use in hydraulic systems. They are stated to be chemically stable and non-toxic, and to have no corrosive effect on steel and other ferrous alloys, aluminium, brass or copper. They will affect, however, magnesium, zinc and cadmium and should not be employed in systems where these metals are used.

NEW CEMENT: NO FEAR OF MOISTURE

Portland cement, coated with a water repellent so that it will not harden or " air-set " when exposed to atmospheric moisture during storage or transit, is to be marketed by the Rugby Portland Cement Company. Wastage by prior setting has previously been serious in the tropics and for the small user who had to store cement from one job to the next. The new product will be sold under trade name of " Pectacrete." Quite literally, every particle of the cement powder is covered during the manufacturing process with a protective coating of a water-repellent chemical. This coating remains intact until it is broken down by the abrasive action which occurs in the mixer; the normal process of setting then proceeds as for an ordinary cement. After setting the water-repellent coating is reformed and a concrete block is almost completely impervious to the penetration of water.

Pectacrete is the result of an all-British research project initiated eight years ago by Sir John Ramsden and Major C. L. Walsh, assisted by the late Major Frederick Webster. Rugby Cement have now begun to manufacture in bulk and say that the price, though higher than ordinary Portland, will more than save the user the cost of wastage due to premature setting. In particular the handyman buying Pectacrete at a shilling a bag more than Portland will not have a half bag of cement rock in his garage when the next job comes along.

Continuing **Metals and Materials**

INTERNATIONAL STANDARDS FOR RUBBER TESTING

TESTS FOR RUBBER-TO-METAL BONDING

By F. H. Edwards, B.SC.*

We now publish the second and third of the three reviews of subjects considered at the seventh meeting of Technical Committee No. 45 on Rubber of the International Standards Organisation (I.S.O./T.C.45), held in Zürich from September 30 to October 5, 1957. The present reviews deal with "Tests for Rubber-to-Metal Bonding," and with the "Testing of Antistatic and Conductive Rubber." The first article, on "Low-Temperature Tests on Rubbers," was published on page 113 of our issue of January 24.

The development of sound techniques for bonding rubber to metal has made possible the extensive use of rubber in engineering particularly for insulation against shock and vibration. For such purposes high-strength bonds are essential, and these are obtained by a chemical reaction which occurs during the curing of the rubber.

Sight must not be lost, moreover, of the many processes for "sticking" rubber to metal, wherein the rubber is normally already vulcanised before being cemented to the metal. Here the forces of adhesion are mainly physical and the bonding is much less strong but suffices for unstressed or lightly-stressed parts.

In the case of the high-strength bonding of rubber to metals it is essential that methods of test shall be available for assessing both the types of material used in the process and the quality of the finished component. As pointed out by Buist and Naunton† "the difference between the two types of testing may be summarised by saying that when testing metal bonding agents one must ensure that the maximum loads or stresses are developed and imposed on the bond whereas the design of a good bonded unit involves the protection of the bond against such stresses by utilising the deformation and damping characteristics of the rubber."

For finished components non-destructive as well as destructive tests are used, always bearing in mind the ultimate condition of service of the component, namely, amplitude and frequency of stressing, shock loads, range of ambient temperature, types of solvent to which the unit will be exposed, etc.

I.S.O. TESTS

Up till the present, a working group of the International Standards Organisation Technical Committee on Rubber, No. 45 (I.S.O./T.C. 45), set up in 1951 under the convenorship of the United Kingdom, has given main consideration to the American Society for Testing Materials D 429 methods A and B for testing the strength of rubber-to-metal bonds. In these methods the "procedures are designed primarily to apply to test pieces prepared in the laboratory under standard conditions such as may be used to provide data for the development and control of rubber compounds and methods of manufacture." Method A refers to a test in which the rubber is assembled between two metal plates, while, in method B the rubber part is assembled to one plate from which it is stripped at an angle of 90 deg.

Both of these methods have been subjected by the working group to considerable experimental investigation in order to resolve the variables and determine the optimum conditions. At the recent Zürich meeting it was agreed that method A, in its amended form, could go forward as a draft I.S.O. proposal but that method B should be re-drafted as a separate document, based on A.S.T.M. D 429-56T, but embodying the latest amendments (such as test piece thickness to be 3 mm. and all the dimensions to be specified in metric units).

In its main essentials, method A consists of a test which measures the force required to cause the rupture of a unit of standard dimensions comprising rubber bonded to two parallel metal plates, the force being normal to the surface. The test piece consists of a rubber cylinder 3 mm. thick and 40 ± 5 mm. in diameter, sandwiched between, and having its circular ends bonded to, the faces of the two metal plates which are of the same diameter as that of the rubber. Fixtures must be provided to permit the accurate centring of the applied load when the test pieces are inserted in the tensile-testing machine. A steady tensile load is applied at a rate of separation of 25 mm. to 55 mm. per min. until the rubber separates from the metal surface or ruptures, the maximum load being recorded. The adhesive strength is calculated by dividing the maximum load by the area of one metal plate surface and is expressed in kg. per sq. cm. Four tests are taken.

The method outlines the preparation of the test unit, wherein the unvulcanised rubber disc is assembled in the vulcanising mould between the metal plates which have been prepared with the adhesive, and the conditions for vulcanisation are specified. In addition to the results of adhesive strength the report must include a description of the type of failure, using an agreed form of terminology, a description of the method of securing the adhesive, the dimensions of the test pieces, the time and temperature of vulcanisation, the temperature at which the test has been conducted and the dates of manufacture and of test.

At the recent I.S.O./T.C.45 meeting at Zürich it was decided that additional methods of rubber-to-metal bonding test should be considered for standardisation purposes. The working group was instructed to investigate static shear tests and it was pointed out that a dynamic test would also be needed.

* Bragg Laboratory, Naval Ordnance Inspection Establishment, Sheffield.

† J. M. Buist & W. J. S. Naunton, *Trans. Inst. Rubber. Ind.*, Vol. XXV, page 400 (1950).

TESTING OF ANTISTATIC AND CONDUCTIVE RUBBER

By D. Bulgin, F.I.R.I., A.INST.P.‡

The high insulation resistance of normal rubber-like materials, P.V.C. and other polymers and resins can be reduced considerably by the incorporation of certain forms of finely-divided carbon black into the mixture. These types of carbon are normally used in the rubber industry for improving the abrasion resistance and other properties of rubbers. Recent discoveries have enabled the insulation resistance of P.V.C. to be reduced greatly by the addition of certain types of chemicals. The resistances obtained are usually higher than those resulting from the incorporation of carbon black but are of practical value in certain circumstances.

The main use of all these materials of reduced resistance is to permit the dissipation of static charges which are readily retained on the surface of materials of high insulation value. The significance of these charges ranges from that of a nuisance value in the cases of the collection of dust on objects or of giving minor shocks from static sparks, to potentially dangerous situations in which a small spark is capable of igniting highly-inflammable vapours or chemicals in the explosives and mining industries or in operating theatres in hospitals.

Many products are currently made in "antistatic" or "conductive" grades of rubber or plastics, as they are termed. Examples are flooring and footwear, aircraft and road-vehicle tyres, castor wheels, hospital anaesthetic equipment, industrial and mining hose and conveyor and transmission belting. The range in resistivity possible is considerable and products can be made from materials ranging from a few ohm-cm. to above 10^{10} ohm-cm. resistivity.

In most cases a resistance of about 1 megohm is the preferred value since, in the majority of applications, static charges can be removed by leakage through a resistance which is of sufficiently high value to avoid fire or shock risk from accidental contact with normal mains supply, but, at the same time, is capable of passing the micro-ampere level currents which are sufficient to reduce static charges to a safe level.

In cases in which extremely low levels of static voltage and charge are required, as when handling detonator materials, a conductive grade of product is used with a resistance less than 50,000 ohms, but adequate precaution against electrical leakage risks must be maintained.

The majority of products are made of rubber loaded with carbon black, and methods of test and resistance ranges are for this type of material. The "antistatic" range for products is defined as being of resistance above 5 by 10^4 ohm and below 1 by 10^7 ohm on new products, while the "conductive" range is below 5 by 10^4 with no lower limit of resistance.

The method of testing these rather new materials has involved considerable research and Mr. R. H. Norman has assembled and discussed published work in a recently-issued book, entitled *Conductive Rubber*, and published by the *Rubber Journal*, London, 1957. Furthermore, two British Standards, B.S.2044 and B.S.2050: 1953, have been issued, the first covering "Laboratory Tests for Resistivity of Conductive and Antistatic Rubbers," and the second "Resistance of Conductive and Antistatic Rubber Products."

The principal difference from rigid materials is the sensitivity of the resistance of the material to its strain history so that a prescribed temperature and time conditioning has to be carried out before the resistance can be defined for specification purposes.

The type of electrode systems applied to the sample or product are important since under certain conditions high contact resistances can arise. For practical purposes the interposition of a film of a conductive liquid between the material and the electrode gives a satisfactory electrode assembly for test purposes while for accurate work either a system of electrodes bonded to the rubber or the use of a potentiometric method are necessary.

During the past two years an international comparison of a test method based on the potentiometric method given in B.S.2044 has been carried out. The input resistance of the potentiometer must exceed 10^{11} ohms to avoid errors due to contact resistance. The work has been carried out for the purpose of specifying an internationally agreed method of test.

At the recent meeting of I.S.O./T.C.45 in Zürich, a draft method was accepted based on the above potentiometric method, with the conditioning of the sample for a period of 2 hours at 70 deg. C. prior to the test to enable stable resistance values to be obtained.

‡ Dunlop Research Centre, Birmingham, 24.

Research and Development

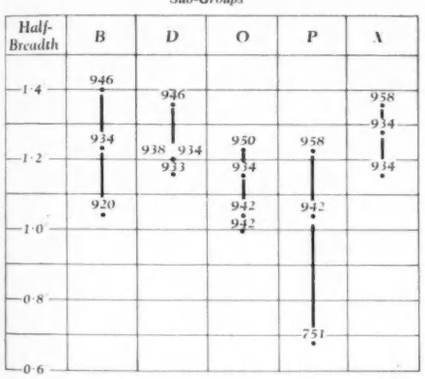
AN INVESTIGATION OF THE STRUCTURAL CONDITIONS IN STEEL BEARING-BALLS

By I. Berz, B.SC., A.M.I.E.E.,*
K. F. Hale, B.SC.,† *and*
C. Wainwright, M.SC.†

Summary.—*Methods are described which are capable of application as non-destructive physical tests of steel bearing-balls, viz: a test for strength by spinning in a rapidly rotating magnetic field, a high-frequency electrical test for surface conditions, and an X-ray diffraction examination. The X-ray survey showed that in the samples examined, the X-ray diffraction lines varied in intensity over the surfaces, so that "polar areas" were found to exist on each ball. These observations could be related to residual flow-line markings seen on etched sections, and so to the processes of fabrication. There was also a correlation between X-ray observations and measurements by the high-frequency electrical method.*

It is a natural consequence of the recent development of high speed engines and compressors that their bearings are subjected to greater loads than has been customary hitherto, a circumstance which has emphasised the desirability of using only components of the first quality. The Research Department of D. Napier and Son, Limited, has therefore made a survey of non-destructive testing techniques, with the hope that it might serve to extend the scope of testing procedures. In this paper it is proposed to describe briefly an equipment which is suitable for stressing bearing-balls by spinning them in a rapidly rotating field, and a high-frequency electrical technique which has been used for examining the conditions in their surface layers. A more detailed description will then be given of an X-ray diffraction investigation undertaken at the National Physical Laboratory in connection with the survey, which has shown that variations in grain orientation may exist round the surfaces of bearing-balls. These variations can be related to internal conditions disclosed by the macro-etching of central sections, and consequently to the processes of fabrication of the balls. A correlation is also found between the X-ray diffraction observations and measurements by the high-frequency electrical technique on the same samples.

TABLE I *Half-Breadths of* (110) *X-ray Diffraction Lines and Corresponding Diamond-Pyramid Hardness Values, arranged in Sub-Groups*



The work so far done during the survey has been exploratory, and there has been no application of the techniques on the practical scale. Since, however, so far as is known, X-ray diffraction observations of this kind have not been reported before, and in view of the correlation with the other procedures, it is thought that the results are worthy of record. Non-destructive testing methods are also of general importance in connection with industrial processes and their products, and from this point of view the results provide a good example of how a knowledge of the characteristics of an industrial product can be developed by the application of a number of physical tests, each of which is capable of contributing a proportion but not the whole of the relevant information.

The problem of ensuring by means of a testing process that the bearing-balls introduced into a bearing are free from significant faults is an extremely difficult one. The tests that can be applied are limited to those types that do not themselves introduce any blemish into the material. It is also evident, for example, that a surface which is itself flawless may conceal a slight defect in the layers just beneath it, and the problem of discovering such a flaw may be insoluble. In the long run, therefore, high standards in the selection of materials and during the manufacturing stages will remain factors of essential importance, over and above any physical testing methods that may be valuable for the observation of variability of one kind or another.

TESTING BY ROTATING MAGNETIC FIELDS

Spinning a bearing-ball by means of a rapidly rotating magnetic field is a direct test for strength, since it may be used to introduce high centrifugal stresses without imposing mechanical constraint, and to break up or explode a ball having significant weakness, while leaving a sound ball unharmed in the same conditions of test.[1,2] The peripheral speeds required to reach the critical condition are of the order of 10^5 cm. per second.

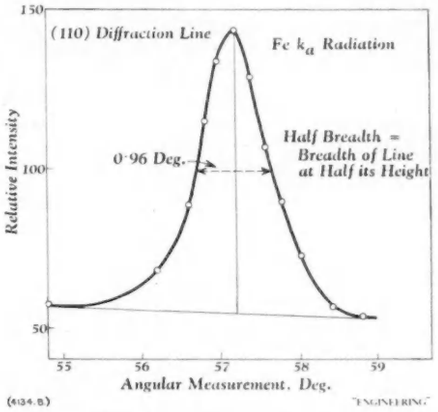


Fig. 1 Intensity measurements across (110) X-ray diffraction line from hard steel surface. Iron radiation.

In these experiments the velocity necessary for critical conditions was reached by accelerating the ball in a rotating magnetic field produced in a stator within which it was located. The rotating field was derived from an oscillator driving a power amplifier which was matched into series and parallel resonance circuits for quadrature fields. The ball was supported on a glass plate with most of its weight balanced by a static divergent field which also provided a radial restoring force. The ball was magnetically coupled to a damping cylinder moving in oil, and damping was critically adjusted to dead-beat conditions. To measure angular velocity the ball was chemically blackened over half its surface and illuminated, so that the resulting signal from a photo-cell gave frequency in terms of a standard signal which was displayed on the same oscillograph.

This equipment has been shown to operate satisfactorily, and ¼ in. diameter balls have been run up to a speed of about 1,200,000 revolutions per minute. With $\frac{13}{16}$ in. diameter balls which were employed for the greater part of the X-ray diffraction and electronic comparator work, the maximum speed was about 600,000 revolutions per minute, this being only about half the bursting speed. Consequently, it has not been possible to apply this technique as a critical test of the balls that were examined by the other methods, though rotation at about half the bursting speed would be expected to bring to light any mechanical defects in the samples. To increase the rate of rotation of the larger balls would have required primarily an increase in the power-amplifier transformer efficiency at the operating frequency, or a higher drive efficiency, and this was not possible at the time of the experiments.

ELECTRONIC COMPARATOR

Electrical methods with alternating fields make use of the permeability and resistivity of the material under test, but the results are also influenced by mechanical flaws which interfere with the magnetic or electrical flux. The depth of penetration is dependent on the frequency generated by the electrical apparatus, and the observations are influenced by variations in the dimensions of the samples.

In the apparatus used for the present experiments, a frequency of 500 kc/s was adopted, the depth of penetration into the steel balls being of the order of 0·001 in. The ball being tested was rotated on a turntable of the gramo-

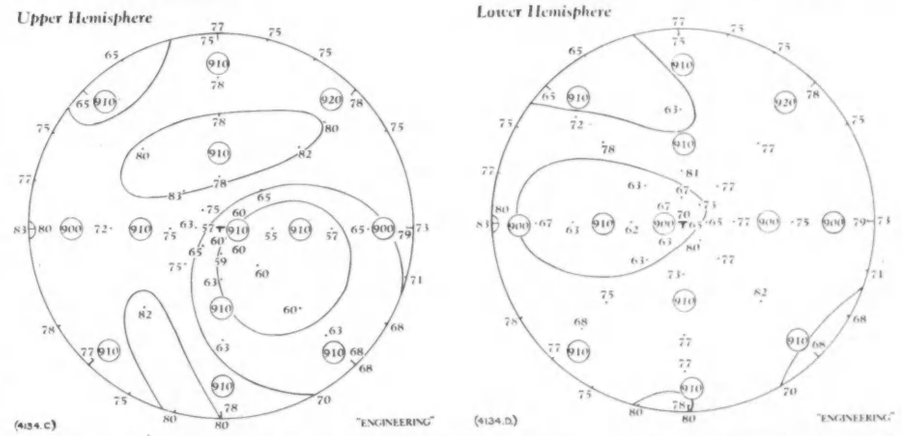


Fig. 2 Intensity measurements of (110) X-ray diffraction line on $\frac{13}{16}$ in. diameter ball. Diamond-pyramid hardness values shown in circles.

* Formerly with D. Napier and Son, Limited. (Now with the National Coal Board.)
† National Physical Laboratory.

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phone type so as to obtain a rapid rotation together with a slower change of axis, thus ensuring that the ball was looked at in all possible ways. Changes in resistivity, permeability, or in physical dimensions, would then alter the characteristics of the oscillatory circuit, resulting in an unbalance which was amplified and displayed on an oscilloscope. Variations between samples were indicated by oscilloscope readings.

X-RAY DIFFRACTION TECHNIQUE

X-ray diffraction methods involve the observation of secondary beams of X-rays that are diffracted at various angles by the crystalline grains of the material being tested. The standard method of operation has been to take a diffraction pattern on a photographic film, the secondary beams appearing as a spectrum of lines. After processing the film, measurements of position may be made and, also, by photometering the distribution of intensity, a line-shape can be obtained. The complete process is a relatively long one, and methods have been developed so that direct readings of intensity can be obtained, using Geiger-Muller counters and electronic circuitry. The process of measurement is thus reduced to a sequence of observations which can be recorded immediately.

This method has been used at the National Physical Laboratory for making rapid surveys over the surfaces of steel samples and thus deriving information concerning the heat-treatments to which they have previously been subjected, the nature of the constituents of the surface layers, and the condition of the surfaces, after working operations such as grinding or polishing. One such investigation, on the dimensional stability of gauge-steel, has already been published[3]; in this case use was made of the fact that the width of the X-ray lines varies with the hardness, or with the degree of tempering. A typical cross-section of an X-ray diffraction line is shown in Fig. 1. It should be noted that the depth of penetration of the X-ray beam is normally about a thousandth of an inch.

PRELIMINARY EXPERIMENTS

About two dozen $\frac{1}{4}$ in. diameter steel balls were withdrawn from stock batches and subjected to X-ray diffraction examination. In order to ensure that all the samples were examined under the same conditions, a small brass cup was fixed at the centre of the spectrometer, and each ball was placed in turn upon its periphery, thus securing identical alignments for all of them. The cup was so arranged that the primary beam of X-rays passed almost tangentially to the ball at the height of its centre, irradiating in this way half of a small cap of the surface. In each case a survey was made of the strong (110) line of the diffraction pattern, and the half-breadth of the curve was measured. The results of the measurements are shown in Table I, together with diamond-pyramid hardness measurements made on the same samples.

The half-breadth values form a distributed array, lying, with one exception, between upper and lower limits of 1·00 deg. and 1·40 deg. The exceptional sample had a half-breadth of only 0·68 deg., and it was concluded that it would almost certainly prove to be considerably softer than the rest of the batch. Table I shows, in confirmation of this, that while the bulk of the samples had hardnesses ranging between 920 D.P.H. and 960 D.P.H., the exceptional one gave a value of only 751 D.P.H. It could be concluded that the X-ray diffraction test was capable of sorting out samples the hardnesses of which differed markedly from the average. There is also a suggestion of correlation between the half-breadths and hardness values for the general group, that is, a higher hardness tends to be related to a greater half-breadth, and more particularly so if a comparison is made between members of the sub-groups; there is then only one instance in which a greater half-breadth corresponds to a lower hardness.

DETAILED SURVEY OF SURFACES

In the above experiments a diffraction curve was obtained for only one position of each ball, which left it uncertain whether the observed differences in half-breadth arose from variations over the surfaces of individual balls, of which the average readings would have been more or less the same, or whether the surface of each ball was substantially uniform, with observable differences from ball to ball. To check this, complete surveys were made over the surfaces of a number of balls, and in order to obtain facility in manipulation and to increase the number of measurements that could be made without overlapping of the irradiated areas, balls of rather more than a half-inch in diameter ($\frac{12}{32}$ in.) were now used.

Equipment was set up as before, with a ball resting on the periphery of a cup, and the X-ray beam irradiating a small area as it passed almost tangentially at centre height. Small fiducial marks were put on the surfaces of the samples by means of Indian ink, and then, with the aid of a circular scale below the cup, it was possible to turn a sample so that observations were made on numerous identifiable areas round the spherical surface. In order to make the survey in a reasonable time, the plotting of a complete line-shape for each position of the ball was replaced by a single measurement at the position of maximum intensity of the diffracted beam. Thus, the Geiger-Muller counter tube rested on the spectrometer circle with its entry slit at the position of maximum intensity for the (110) line, and a single reading was obtained for each position of the ball. The observations were made with an initial assumption that although hardness differences would alter the line-shapes, they would not alter their areas to the same extent, so that an increase in width would be accompanied by a more easily measured decrease in height, and vice versa.

Fig. 2, on page 151, shows the stereographic projections of the readings obtained from one sample; the projections may be considered to represent two hemispheres of the spherical surface, there being a little positional distortion due to the impossibility of depicting a spherical surface with complete accuracy upon a plane. Fig. 2 shows that on the surface of the ball there are two polar areas from which low readings were obtained, surrounded by an equatorial region of high readings, and this result was typical of the readings from all the balls that were examined.

The observations were first considered in terms of hardness variations, but when check measurements were made by plotting complete curves from areas giving high and low readings, the curves proved to be identical in shape, differing only in absolute intensity. Measurements of hardness then showed that each of the balls was uniformly hard over its surface. The next step was to investigate the possibility that the various intensities were due to a preferred orientation of the crystal grains of the material. It is well known that when metals are worked and made to flow plastically by rolling, forging, or similar processes, a rotation of the grains of the material occurs, so that certain planes of atoms of the crystal structure of each grain tend to be in particular directions in relation to the direction of flow. Then according to the relationship with the direction of an impinging X-ray beam, there will be available more or less than the average number of planes of a given kind to produce the corresponding diffracted beam, which will consequently be more or less intense than for random distribution of the planes.

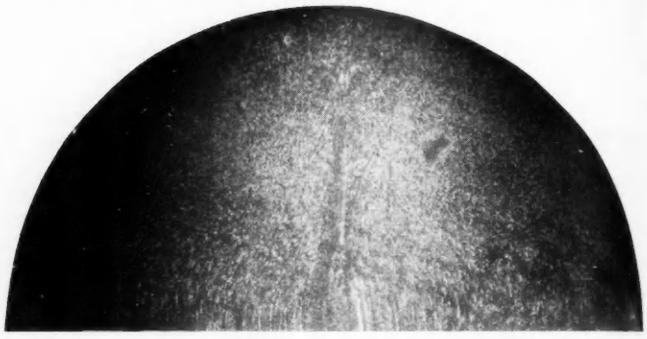

Fig. 3 Macro-etched section of $\frac{12}{32}$ in. diameter ball, showing residual flow lines.

It is also known that when a bearing-ball is sectioned on an appropriate central plane, and etched, residual flow lines are to be seen which are an indication of the original heavy working of the bar from which the ball was fabricated. In order to discover whether there was a connection between the X-ray observations and such flow-line phenomena, several samples were sectioned along central planes, so as to obtain from each a hemisphere with its plane face passing through the centres of the low-reading areas defined by a previous X-ray survey, the circumference of the plane face of the hemisphere then containing two diametrically opposed low-reading areas, and two high-reading regions at right angles to them. Fig. 3 shows a half of the etched central plane of the ball which had been used to produce Fig. 2, and its fibre structure is clearly seen.

The hemisphere was then replaced on the X-ray spectrometer, with its plane face horizontal, and readings were taken as before round the circumference of the section, when the fibre axis was found to join the low-reading areas, while regions at right angles gave the highest readings. Thus the directional fibre-axis structure within the ball was precisely related to the X-ray observations from the surface.

It was concluded that the grains of these bearing-balls retained directional characteristics

TABLE II *Comparison of X-ray Diffraction and Electronic Observations*

Ball	Polar area	Reading at poles	Reading at Equator	Difference	Average diff.	Electronic comparator reading	Average comparator reading
G	Small	70	75	5		1·8	
L	Small	80	85	5		1·5	
A	Small	85	91	6		2·3	
B	Small	77	84	7	6·7	1·7	1·8
I	Small	71	79	8		2·0	
K	Small	81	90	9		1·4	
E	Medium	75	84	9	11	2·4	2·7
C	Medium	75	88	13		3·0	
H	Large	70	80	10		5·3	
F	Large	70	81	11		4·5	
J	Large	75	89	14	12·5	4·0	4·6
D	Large	75	90	15		4·7	

which were introduced by the forming processes applied to the bar from which they were made.

COMPARISON OF DIFFERENT METHODS

A group of twelve $\frac{13}{16}$ in. balls was subjected to the X-ray test to find whether all of them would display low-reading areas. The first result was the observation that although polar areas were present in all cases, there was a considerable difference in the size of the polar area from one ball to another. There was also a definite tendency for the differences between the low readings at the poles and the high readings at the equator to be greatest when the low-reading areas were large. It was also noted in the samples which were sectioned that a small polar area corresponded to a narrow well-defined polar axis, and a large polar area to a more extensive central region with the fibre-axis characteristics.

The observations are set out in Table II, the polar areas being given the general descriptions large, medium, and small. The actual testing order was that shown by the letters of the first column, but the comparisons are more easily visualised when the results are set out, first in the order of sizes of polar areas, and secondly according to the values of the differences between polar and equatorial readings. In this way averages can be obtained (column 6) for the small, medium and large area groups. There is clearly a relationship between the descriptive values of the polar areas and the differences between low and high readings.

In columns 7 and 8 are shown the actual and the average values obtained when these balls were tested in high-frequency equipment of the kind already described. Visual examination suggests that there is a correspondence between the electronic comparator readings and the difference values of column 5, and more precise information has been provided by the Mathematics Division of the National Physical Laboratory, who showed that the probability of this correspondence occurring fortuitously is less than one in a hundred. It is proper to conclude that a real relationship exists.

These observations can be further related to the known variation of permeability with direction within a single crystal of iron or steel. When directional preference exists in a steel sample so far as the orientation of the grains is concerned, permeability differences should also be expected in proportion to the departure from randomness, with an equivalent influence upon the observations obtained from a high-frequency electrical device. The experimental results from the various techniques are therefore self-consistent.

Acknowledgments.—One of us (I.B.) wishes to acknowledge the interest and encouragement of Mr. L. F. Hall, Research Engineer, D. Napier and Son, Limited, during the progress of the work. This paper is published by permission of D. Napier and Son, Limited, and of the Director, National Physical Laboratory.

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The Postmaster General announces that Sir Lawrence Bragg, O.B.E., M.C., F.R.S., has kindly consented to become the chairman of the new committee which is to advise him on broad aspects of frequency allocation. Also that he is appointing to the committee members representative of the radio industry, users organisations, and government departments. The committee will hold its first meeting as soon as its membership is complete, which is expected to be early this Year. It is expected that the committee will enable both users and industry to be associated more closely with frequency planning.

AUTOMATIC AIDS TO TELEPHONE MAINTENANCE

Developments by G.P.O.

The London automatic telephone network serves some 1·35 million exchange lines, having about 2·25 million telephone instruments connected to 235 automatic and 56 manual exchanges by nearly 2·5 million miles of pairs of paper-insulated copper wire in lead-sheathed underground cables. About 35 million telephone calls are made over the network every week.

Three automatic devices have been developed by Post Office engineers in London to aid the maintenance engineers in reducing the chance of faults. The devices should lead to substantial reductions in the cost of maintenance.

Automatic Tester for Installers

This device is installed at the exchange. When a telephone has been installed, the technician at the subscriber's house is able to dial a code number and be connected with the test equipment. Previously he had to call the exchange and ask the assistance of a member of the staff there. The test equipment is fitted with a magnetic recording and, as it runs through a set sequence of tests, it reports verbally to the installer any fault that it finds. The test takes 15 seconds. Should a second installer call the device while it is in use, his call is held and connected as soon as the equipment is free.

In practice the operation would proceed as follows: the installer would dial the code number of the automatic tester followed by the number of the subscriber's telephone. The equipment would tell the installer to start the test. The installer would then replace the receiver and the insulation of A wire, of B wire, and between A and B wires would be tested by the exchange equipment. The equipment then rings the subscriber's bell and when the installer lifts the receiver the loop resistance is tested. The installer then dials another code number and the dial operation is checked by the exchange equipment. The installer can then be put in touch with the test clerk at the exchange for instructions to go to another installation. To cope with various situations the magnetic drum carries 12 different speech tracks.

Automatic Telephone Subscriber

This device, which will be fitted to all the automatic exchanges in the Greater London Area, makes a continuous series of calls to special numbers at all other automatic exchanges in the network. The device verifies that the correct number has been obtained. If a technical fault prevents completion of a call the connection is held and an alarm given. The staff at the originating exchange then trace the connection to find what has gone wrong.

The possible combinations of lines and exchange equipment that could be used to complete a telephone call from a private branch exchange in the City to a subscriber on, say, Harrow exchange amount to several hundred thousand. It is almost impossible to repeat the particular combination that gave rise to a complaint of call failure and so this device has been developed to help in locating the cause of such failures.

At the same time that a call is made successfully the metering equipment that records call charges is checked. The equipment can be made to hold three calls so that the same number can be dialled three times and three different routes will be tested.

Routine Line Insulation Tester

Faults on subscriber's telephones may take some time to develop. This third device checks the lines at regular intervals for reduction of insulation resistance. By adopting a fairly high standard resistance of 2 megohms, it is easier to trace falling resistance. Previously the tests were done by manual dialling of the subscribers numbers, and as the work was extremely monotonous, checking of a 10,000 line exchange might have to be spread over six months. The new equipment tests the lines in numerical order at the rate of 600 an hour and a record is made of the exchange number of any line that fails the test. An examination of the cable route taken by this exchange line will then reveal the incipient fault in a particular section. Thermistors in the equipment prevent the subscriber's bell ringing during the insulation test.

The work of installing this new device in all London exchanges has already started and should be completed by the end of 1958. The tracking of incipient faults will also tend to improve the service given by all automatic exchanges.

DEVELOPING POLARIS: 40 FT. SHOCK TUBE

Development of the United States Navy's solid-propellant fleet ballistic missile, Polaris, is primarily the responsibility of the Lockheed Aircraft Corporation, Burbank, California. Polaris has a range of about 1,500 miles and is designed for launching from naval craft, including submarines. A fresh financial appropriation of £18 million emphasises the importance attached by American defence chiefs to the new missile which, they have stated, is "the focal point in a sweeping new concept of United States defence strategy."

Most of the development work is being conducted at Lockheed's new missile research centre at Sunnyvale and Palo Alto, California. Tests are also being made in the remote Santa Cruz Mountains.

At Palo Alto, a large new shock tube, capable of testing ballistic missile designs at 13,000 m.p.h. is being used for advanced design work on Polaris. A 40 ft. long stainless-steel tube, it produces shock waves which travel at 17 times the speed of sound. The temperatures and pressures generated within the tube simulate those encountered by a long-range ballistic missile on re-entry from space into the earth's atmosphere. Platinum resistance thermometers 0·000 001 in. thick are used to record the temperatures.

In the shock tube, the build-up of gas under pressure at one end ruptures a thin diaphragm when the pressure reaches a certain level. The high-pressure gas then expands down the tube behind a hypersonic shock wave. The Lockheed tube has an inside diameter of 3 in. and walls $\frac{1}{2}$ in. thick. At the end is a "dump chamber" 18 in. in diameter and 3 ft. long which absorbs the shock wave and thus avoids excessive pressures by reflection. An interferometer, using a system of mirrors which must be adjusted to within 0·000 0001 in., records the gas flow.

PROCESS RESEARCH STATION

To extend their activities in the chemical engineering and automatic control fields, Constructors John Brown Limited have recently established a research and development station at Leatherhead, Surrey. The chief object of the station will be to undertake sponsored development work on behalf of government departments, industrial organisations, and the engineering and construction division of Constructors John Brown. The following fields will be covered: process development and the investigation of chemical engineering problems; development of automatic control systems and their application; special problems of nuclear engineering.

Book Reviews

ON THE GRAND SCALE

Hydro-Electric Engineering Practice. Edited by J. GUTHRIE BROWN. **Volume I: Civil Engineering** (189*s.*). **Volume II: Mechanical and Electrical Engineering.** Co-ordinating Editor, P. L. BLACKSTONE (126*s.*). **Volume III: Economics, Operation and Maintenance.** Co-ordinating Editor, J. K. HUNTER (84*s.*). *Blackie and Son Limited*, 17 *Stanhope-street, Glasgow, C.*4.

In endeavouring to assess the value of an encyclopaediac work of the scale and scope of this new three-volume survey of hydro-electric engineering practice, it is first necessary to establish the criteria by which it is to be judged. Is the work intended primarily as a vade-mecum for the practising engineer engaged in the design of hydro-electric plant? If so, does it, within its own vast compass, contain all he needs to know if he is to plan a water-power scheme, build it and put it into action? Is it intended for the student? If so, does it start sufficiently near first principles for him to be able to benefit from what follows? (The publisher's note claims that it is of equal use to the established engineer and the advanced student, but the needs of these two classes of readers are in practice very different.) Is it as comprehensive as it claims to be? Is it as up-to-date as may reasonably be expected? As for the authority of the books—they are largely the product of collaboration between two great firms of British consulting engineers: Sir Alexander Gibb and Partners, and Merz and McLellan, whose collaboration in the assessment and design of power schemes throughout the world is almost unparalleled.

The answers to the two questions first posed do not emerge as clearly as might be hoped. In the case of the first volume, devoted entirely to civil engineering, the answers must certainly be that its exhaustive treatment and its great store of data cannot but exceed the knowledge any individual engineer can carry in his head or in anything but a small library of books and journals. It begins its course with a discussion on rainfall, leading the reader through flow measurement to hydraulic theory and on to the overall design of dams of every kind. This volume can be commended almost without reservation, even when regarded in the light of all the criteria postulated above taken together. The authors have drawn their examples from a wide range of projects and the extra-parochial outlook is of particular merit. For example, in the chapter on embankment dams (and elsewhere), due attention is paid to the design of structures for building in earthquake areas.

It could perhaps be said of this volume that not enough attention is paid to the most modern methods of rationalising hydro-electric construction work, particularly those emanating in the U.S.S.R. and elsewhere and described in the Economic Commission for Europe's United Nations report E/ECE/EP/185. Although this report was only published in June of last year, and the book must have closed for press at about that time, the techniques described in this report have been in use for at least two or three years. To take an instance, the earthwork part of the Kuibyshev dam, built during the last five years, has embodied in it over 100 million cub. metres of earth fill, all moved by hydraulic means; yet what is apparently the main reference to this important advance in construction methods occurs on page 359, in a single short paragraph. The commencement of the relevant chapter (on embankment dams) includes the statement that the Garrison dam (in the U.S.A.) contains a greater volume of earth, 70 million cub. yards, than any other dam so far constructed. But the Kuibyshev project, with 150 million cub. metres of earthworks in all has involved nearly three times the quantity of earthwork required by the Garrison dam design (see report of the British delegation from the Institutions of Civil, Mechanical and Electrical Engineers who visited the U.S.S.R. in 1956, presented to the Institution of Civil Engineers on May 20, 1957).

Nevertheless, this volume is a veritable bedrock on which each engineer's own experience can build. In it are all the essentials, both of theory and practice. From the major considerations of overall design of intake and outlet works right down to such humble advice as that given to power station interior designers to provide " at all uncovered deep pits an upstand curb to prevent tools, etc., being kicked over the edge with consequent danger to personnel or plant " (page 1041), the volume fulfills its task as guide and friend. And in its concluding sections on the aesthetics of hydro-electric structures it even becomes a philosopher as well: " all of these changes (the construction of water power projects) create excitement, dismay and opposition from the landowners concerned. The threat to scenic beauties also brings into action various societies for the preservation of the *status quo* and, finally, the general public become alarmed and take sides, generally against the new scheme."

The second volume is divided into four sections: water turbines, electric generators, control and transmission equipment, and power station planning. The contents of the turbine section are naturally sub-divided into the Pelton wheel, Francis and Kaplan designs. After a general introduction, each is carefully described, theoretically and from the constructional point of view.

As a test case, to check the completeness of the range of turbine designs set out in this section, the interesting " bulb-type " units, installed in France at the Castet station and now to be installed in the Rance tidal power scheme, were chosen. This is a significant development, since the experienced French engineers who have evolved these totally-immersed units claim substantial advantages for this design for the smaller yet economically important stations. Recent hydrological surveys in a number of countries have shown that some of the smaller hydro-electric projects are capable of yielding greater outputs than was at first thought, and these inexpensive turbo-generators, operating at very low heads, are likely to enjoy considerable popularity in the near future. It was not found possible to locate any reference to these bulb-type units in the appropriate volume.

On the credit side, the difficulties due to cavitational problems in Pelton, Francis and Kaplan type turbines are set out with great clarity and with every possible practical assistance towards their solution. Governing is also very clearly described, and the relatively new electronically controlled actuators, as used extensively in Sweden and elsewhere, are mentioned if not discussed at length.

In dealing with generator construction the authors give a comprehensive range of examples of designs for most sizes and speeds, and pay due tribute to the advantages nowadays obtained by completely fabricated construction. But for a vade-mecum the book is rather lacking in advice on erection problems arising on site. The difficulties sometimes associated with drying out, and the awkward moments that can arise during commissioning tests are more likely to send even the most experienced engineer to his site office for a surreptitious peep at a text-book than are any design problems, which usually arise in places where a hundred times more information is available than could be contained in any single volume, however exhaustive.

The switchgear, protection and transmission sections of volume II provide an adequate survey of practice up to a voltage level of 275 kV, with glances at higher voltage systems. The examples chosen for detailed illustration show practice as it was about five years ago. The Swedish 380 kV system (inaugurated in 1952) and the Russian 400 kV system (made alive in 1956) are not mentioned; this is surprising in view of the adoption of the 330 kV level (as in the Kariba project) and the 300/400 kV level in a number of countries where water power is predominant, for example the United States, France and part of Western Germany.

A chapter which may be of especial use to those planning hydro-electric stations in remote areas will be that relating to control and communication equipment. The training of the average engineer concerned with hydro-electric development includes little to fit him to assess the merits of light-current equipment, and he may well seek guidance in this field. Here the only criticism is that insufficient attention is paid to the carrier-current equipment now so extensively used, particularly in America. Where the high-frequency currents meet the power-line frequency and voltage is the point where troubles may occur, and where an engineer needs both heavy current and light current knowledge and experience.

In view of the greatly increased interest in pumped storage schemes now apparent (mainly deriving from their application as ideal partners with nuclear plants) the chapter near the end of volume II devoted to such schemes will be of particular value. It is one of the best chapters in the whole of the three volumes, and brings together in one place information not readily accessible elsewhere.

Volume III deals with the economics, operation and maintenance of hydro-electric plants. The first section, on economics, presents the reviewer with a puzzling problem. This is a text-book on hydro-electric engineering practice; what type of reader would want to know that " the ease with which electricity can be transmitted long distances and distributed over wide areas, and the facility with which it can be applied to a multitude of purposes render it the most convenient form in which power can be produced " (page 9)?

The puzzle as to the intended readership continues as this section is pursued. There are tables showing 1950 figures for world production of energy in various forms, excluding in most cases the U.S.S.R. and other " iron curtain " countries. If such tables are relevant (and this is not necessarily so) then O.E.E.C., U.S.A. Bureau of Reclamation, and World Power Conference figures of much more up to date origin have been available for some time, and U.S.S.R. figures have been freely quoted at such meetings as the Geneva Conference on the Peaceful Uses of Atomic Power held in 1955, C.I.G.R.E. in 1954, and the World Power Conference in 1956. It is true that 1953 statistics are used in places, but with few exceptions this appears to be the latest date of compilation, for a volume emerging from the press in 1957. In these last years the world pattern of power production, particularly in the areas where great schemes of water power are either under way or in immediate contemplation (for example, Kariba, the Belgian Congo, Siberia and Northern India), has changed considerably, and the conclusions drawn from the statistics given in this section may no longer be valid. Above all, the nuclear power generation pattern has emerged. The reviewer cannot but wonder why it was thought necessary even to consider including the brief survey (in Appendix III) of the nuclear power position, which could have been easily envisaged as being out-dated almost immediately, from the stated standpoint of 1955.

The exposition of the more detailed aspects of hydro-electric economics, in the succeeding chapters in the third volume, come as a relief after the generalisations which mar its intro-

duction. The sections on interest rates, obsolescence, and amortisation periods are full of prudent judgments which will be of assistance not only to engineers but to the commercial managements of all power undertakings. The analyses of the effects of varying load factor on the economic feasibility of new projects is a study which can never become out-dated. There then follows a number of chapters on advances in civil engineering and trends in the development of generating plant. These subjects were dealt with *in extenso* in volume II, and the material added here is of the nature first of duplication and then of postscript.

The next chapters deal with the management, operation and maintenance of all aspects of water power plant, and here the advice given is extremely comprehensive and practical. These chapters are among the most valuable in the whole work.

All the three indices are very well done; though they are not very long it is easy to find any desired reference quickly. The type size used throughout the work is rather small and there are unusually wide margins—one can hardly be expected to annotate the text on the glossy paper provided. The illustrations are uniformly excellent where diagrams are concerned, but many of the photographs are reproduced on too small a scale to be of real value or interest.

These three volumes contain a mass of data never before collected in similar compass, and if it is desired to acquire the fundamental bases of hydro-electric practice then there is no better source. Inevitably, in a work of this scale, taking years to plan and edit, there are omissions which will be apparent to specialists in their own particular fields, but the authors, editors and publishers have done a great service to engineers and engineering.

FUNCTIONS OF MICRO-RECORDING

A symposium on "Micro-Texts and Micro-Recording" was held at the Technical College, Hatfield, on January 14. The chairman, Mr. T. G. Mercer, explained that when it was realised that the library of the College would require some form of micro-reproduction, it was also realised that there was very little non-commercial and therefore unbiased information available on the subject. The librarian had felt that others might appreciate the benefit of his experience and that was how the symposium had come about. Mr. Mercer then introduced Mr. H. R. Verry of the organisation and methods department of H.M. Treasury.

The lecturer first gave a definition of micro-recording and then explained its function, namely, to reduce space. He went on to describe the two basic types—roll-film and "flats," the latter including micro-cards and micro-sheet (or micro-fiches). Each has a different purpose.

"Flats" have developed much later than film and are really still fighting their battle for recognition. Film, for instance, has an advantage in that it is better for subsequent re-enlarging. Mr. Verry described methods of photography on both 16 and 35 mm. film and gave figures such as 18,000 documents (cheques in this case) on one roll of film and a rate of 20,000 documents an hour. These would be on 16 mm. film but for the reproduction of material such as books he recommended 35 mm. film, where two facing pages can be printed on one frame. He pointed out that the quality of the original document must also govern the type of film used, since poor material cannot be reduced to a great extent and still give a clear reproduction in a viewer. Most important is skill in photography. A poor original will require great care, especially if it is to be re-enlarged.

Discussing micro-card (opaques) and micro-sheet (translucents), Mr. Verry said that while the latter gave better definition and could be used with a cheaper reader or viewer, micro-card had a psychological advantage. Micro-card can also be used on the reverse side for such purposes as abstracts in normal type and catalogue notations. There is a growing tendency to put the abstract on the *same* side as the photographs at the top of the card. Cards are usually the standard 5 in. by 3 in. but there are also 6 in. by 9 in. cards which encompass 100 images. The latter claim a greater durability since they are lithographed and usually are taken from 35 mm. film. There is a further process which uses 200 images but the cost of the camera makes this prohibitive for most commercial purposes and it is used chiefly by the legal fraternity.

Another process produces opaque rolls from cinema film. The backs of the frames are adhesive and the rolls can then be cut and fixed to cards.

Mr. A. J. Brockbank opened the proceedings after the luncheon interval with a description of the application of microphotography in the offices of Glaxo Laboratories. He visualised applications to accounting, stores procedure, goods distribution, archives and litigation with particular regard to patents. The main application is in the reduction of paper work in accountancy. Where three copies of each invoice were once made, only one original is now typed and then filmed. This met with opposition from the auditors but once they were convinced that they need not have a piece of paper on which to put their pencilled ticks their opposition faded.

Thus, at the end of five years, the accounts department has 250,000 documents committed to film and every invoice copy clearly legible. The degree of reduction used is 20:1 which, it has been found, combines clarity and maximum economy. A continuous-flow camera is used as it is found that this gives better results for the purpose than a vertical camera. It has a greater speed and demands no technical skill. Some 12,000 documents a week can be recorded by this means. Under the old traditional system, the invoice department needed a staff of 13. With micro-filming only three are needed and the number of filing cabinets required is reduced in a similar way. On film, the cost of an invoice copy is 0·2*d.* and the cost of a carbon copy works out at 0·5*d.*

Another development of this system is in dealing with queries. A central "queries and reference section" has been set up round the file of film. In time this department has so developed its own efficiency and sense of anticipation, through specialising in queries alone, that a staff of three now deals with all inquiries connected with accounts in a shorter time than was the case under the old system, and the expense of departmental film-readers and the bother of sending film round is obviated.

One respect in which it is not felt satisfactory to use film is correspondence, where an initial letter is likely to promote subsequent correspondence.

The final paper, on "Handling, Filing and Indexing," was given by Miss M. Gauntlett of the Kodak research organisation. Her *forte* is, naturally, film, but this did not deter her from dealing with the other methods. Of special interest to readers of this journal was her reference to the use of 70 mm. film. This is particularly useful for the reproduction of plans and engineering drawings. British Standard 1371, covering micro-film, readers and reels, was suggested as a guide to those about to embark on a micro-film library. Normally, a 1:10 to 1:12 reduction gives two pages to a frame.

Storage conditions need some thought and care, particularly if the material is archival. A normal living atmosphere should be satisfactory and British Standard 1153, covering: recommendations for the storage of micro-film, gives adequate guidance on this point, both for commercial and archival requirements.

Held in conjunction with the symposium was an exhibition of manufacturers' products.

On the Shelf

By Frank H. Smith

It is difficult to gather from my source of information whether the specialist publishing houses now appearing in Russia are Government affairs or private enterprises. One can think of plenty of firms in this country which publish nothing but children's books, for instance, but the phrasing of a paragraph I have just read implies some sort of sponsorship. It goes like this, "A new publishing house—'The Children's World'—has been set up in Moscow to cater for children between the ages of three and seven." Add to this phrasing the fact that the concern will publish 27 books about machines and those who make them, about forests, mountains and oceans and about the harnessing of nature, and one gets some idea of how the Russians lay the foundations of technological education.

Chapman and Hall (their telegraphic address is "Pickwick"—a name to which they have a particular claim) announce that as from December 1 last year they have been appointed publishers of books to the Institute of Physics. They are not, however, responsible for those already published by Arnold, and the Institute itself will continue to publish *The Journal of Scientific Instruments* and *The British Journal of Applied Physics* with their supplements.

What "Mudies," "Boots" and "The Times" are to the general subscription-library reader, "Lewis's" is to the technical student who wishes to pass examinations without spending vast sums on books. H. K. Lewis and Company Limited, 136 Gower-street, London, W.C.1, have just published the latest catalogue (to December, 1956) of *Lewis's Medical, Scientific and Technical Lending Library* at 25*s.* to subscribers and 42*s.* to non-subscribers. The library was originally established in 1848 to meet the needs of the medical profession, but it has been expanded to cover the whole field of technology and science, and a general survey of the subscribers makes interesting reading. "There is only one class of subscription, which entitles every subscriber to the best service the Library can render." This could well be taken as a goal for every librarian in the world.

The catalogue is primarily on the "author index main entry" basis and under each author will be found the title, size, price, edition (if other than first) and date of publication. This is Part I, constituting the first 830 pages. Part II is a classified index of subjects "with names of authors who have written upon them." The classification consists simply of subject headings, starting with abdominal and working from abortion, acidosis, acoustics through to zoology, vertebrate. Under each subject heading are given in alphabetical order the authors and the dates on which their books were published so that it is a simple matter to find the title, etc., in the first part. The only thing that is missing, in fact, to make it an indispensable library tool is the publisher's name. The omission of this is understandable, as Lewis's are booksellers.

The last issue of 1957 of the *Unesco Bulletin for Libraries* has special articles on the use of audio-visual aids in the library most of which boil down to the necessity for libraries, these days, to file films, particulars of television programmes, gramophone records, recording tapes, and the like. The implication is (and rightly so) that for sheer education speed the picture has the printed word beaten all down the course. And not only teaching. I lay myself open to being called a moron when I admit that I have never been able to read Dickens. Yet I recently sat entranced through every episode of a television version of *Nicholas Nickleby*. Many librarians will tell you that the cinema and TV do not influence reading to any great extent, but I say they do. And when libraries meet the "square-eyed" fraternity more than halfway, I feel that they are committing "bibliocide." At the moment there is an amazing boom in record-players. The next step will be film-projectors.

Special Article

WATCHING THE SHIPS GO BY

Calshot tells them Where they are and What other Vessels are Doing

Fig. 1 Calshot Signal Station stands at the entrance to Southampton Water. It provides navigational information for vessels approaching and leaving the port and refineries.

Many vessels see Southampton Water. Naval ships in the Solent, tankers entering the refineries, liners and cargo vessels berthing at the Port of Southampton. Few channels are as full.

Liners and other shipping using the docks have a different way of operating to tankers serving the refineries. The contrast in their timetables is marked. Passenger ship schedules are set down in advance, but the demands of the refinery play a part in the timing of tankers. A reliable 24-hour forecast of tanker movements is hard to get.

Co-ordination of the various ship movements is carried out by the duty port operations officer in Calshot Signal Station. He is responsible to the harbour master. Vessels are watched as they pass through the port and navigational information is passed to any that asks for it. Each is controlled by her master and pilot. The harbour master can ask a ship to stay moored or to delay her entry into the port, but he gives no manoeuvring instructions. The division of duties is clearly defined.

A new installation at Calshot will greatly aid the smooth running of shipping. Radar and v.h.f. telephony have been fitted. The Minister of Transport and Civil Aviation, who formally opened the new facilities recently, said: "The radar system provides a complete picture of what is going on in the harbour and its approaches. I am told that it can achieve a finer discrimination between targets lying close together than can any other comparable radar installation in the world. The very modern v.h.f. communication provides a way of seeing that everyone who needs information can get it without interference or delay.

"It is the first installation of its type in this country which conforms fully with the requirements agreed at the International Maritime v.h.f. conference held at The Hague just a year ago."

The Port Operation and Information Service has been under consideration for the last ten years. Calshot Signal Station forms an ideal geographical centre. It stands at the entrance to Southampton Water, with a commanding view of the eastern and western port approaches from the Solent. Just to the north-west is the petroleum area where considerable development is taking place. On the east side of Southampton Water is the installation of Shell-Mex and B.P. Limited. Almost immediately opposite the station a jetty to serve a refinery in the Hook area is being considered.

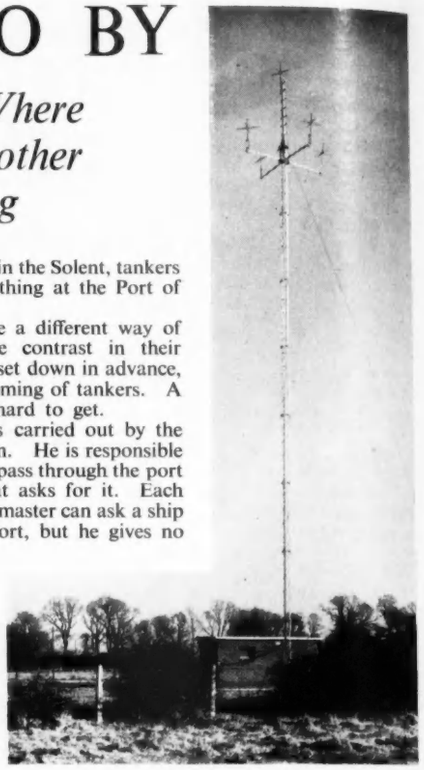


Fig. 3 The v.h.f. transmitter for frequency modulated telephony is controlled from the signal station.

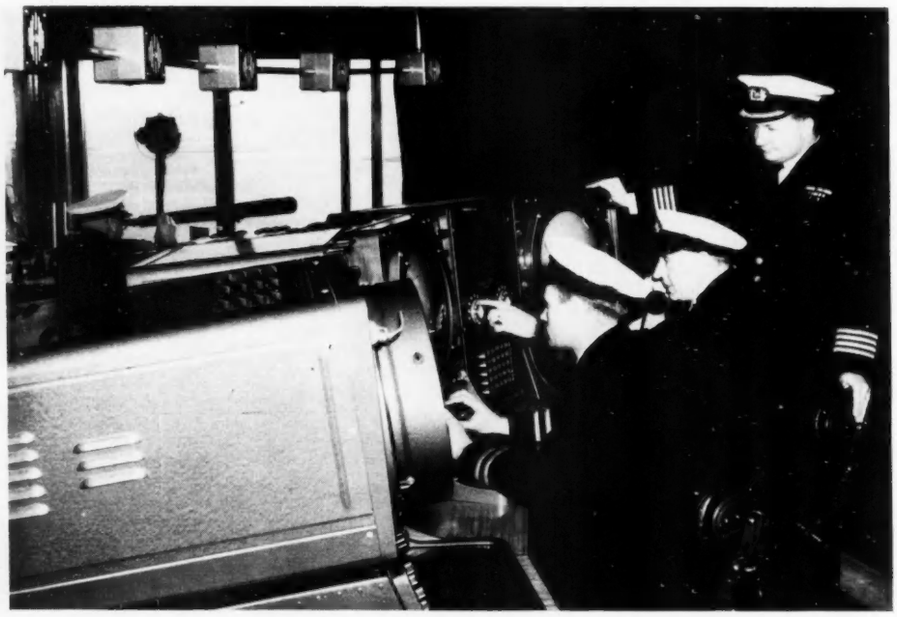


Fig. 2 The operations room in the signal station contains a crescent-shaped console which three radar viewing units fit into. Between them stand the v.h.f. telephony control panels.

The main castle building at Calshot dates from about 1538. Upon its very substantial walls the Air Ministry built a two-storey air-control station in the 1940's. The new building now there had to be designed with weight and wind loading as low as possible. Steel frame construction is used with 4½ in. flint-brick panel walls, lined with vermiculite slabs. The floors and roof are pre-cast hollow reinforced concrete units. A large window space in the upper floor faces all navigable channels. The roof level is about 78 ft. above Ordnance datum.

The plan of the building was fixed to some extent by the shape of the structure below. But it was found possible to have two floors of 280 sq. ft. These were sufficient for the radar, telecommunications, and recording equipment—on the lower floor—and the desks, radar console, and signalling gear—on the upper floor. Welded tubular construction is used for the radar scanning tower to give rigidity without too much wind resistance.

The development of v.h.f. maritime radio telephony has been delayed for a number of reasons. The chief was disagreement on the type of modulation to be used. Agreement was finally reached at The Hague conference. Following this, the Southampton Harbour Board, in consultation with the Ministry of Transport and Civil Aviation, the General Post Office, the Chamber of Shipping, the Liverpool Steamship Owners' Association, the Radio Advisory Service, the British Transport Commission, the Esso Petroleum Company Limited, and Shell-Mex and B.P. Limited, drew up the system that has now been put in at Southampton. The shipowners' objective has been a simple one. Namely, that any ship provided with v.h.f.

radio telephony equipment of reasonable size should be able to use the v.h.f. services afforded by any port in the world and by any coastal correspondence station.

The Hague conference achieved two major results. Firstly, it fixed on a system of frequency modulation to be used internationally for v.h.f. ship-to-shore communications. Secondly, an agreed frequency plan was drawn up. A number of channels in the 156-162 Mc/s band were allocated for specific uses: the calling and safety channel always occupies a frequency of 156·8 Mc/s. It will be used by shipping to make initial contact with the port.

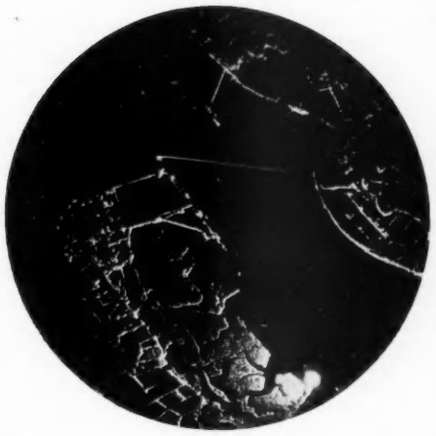
When a ship has made contact she can ask for the service she wants—navigational information or docking instructions, for example. The coast station can then tell her the channel used for the service. Channels allocated for this purpose are known as port operations channels. A total of 16 are available: five work on a single-frequency basis, the rest on a two-frequency basis. The number used by any port authority will depend on the amount of traffic through their port. At Southampton four, in addition to the calling and safety channel, are provided; but the system can be expanded. All channels can be used at the same time and the system gives a coverage over an area extending from the docks to about 20 miles along the Solent.

The specification for a harbour surveillance radar was prepared by the Ministry of Transport and Civil Aviation's radar research group. A marine radar equipment was temporarily installed at Calshot and observations were carried out for two months. Good coverage of the West Solent for a distance of six miles from Calshot was obtained but the Solent Banks area was found to be shadowed by the high wooded land to the west of Calshot.

The lattice tower now carrying the radar aerial stands on top of the signal station. Two 3 cm. Type 32 transmitters and receivers with changeover facilities are fitted in a compartment at the base of the mast. In the information room on the top floor of the signal station three display viewing units are arranged on a crescent-shaped console. The two control units for the v.h.f. and radar equipment are placed between them. The displays measure 15 in. in diameter and each can show any one of five operational areas.

The five are derived from one set of echoes. The basic picture extends about 18 miles from Calshot and includes coverage of the Nab. It is referred to as display area number 5 and

Fig. 4 Display area number five. The interscan range and bearing marker is set up between the Fawley Beacon and a buoy off the entrance to the Hamble River.



functions as a small-scale general warning display. Three working display areas of a larger scale, numbers 2, 3 and 4, cover: Southampton Water itself, the western approaches from the Solent (including Ryde and Spithead), and the eastern Solent (including Cowes Roads). Display number 1 is a large-scale view of the petroleum terminals. Fig. 5 shows the areas covered by the various displays.

Each of the three P.P.I. viewing units has four fixed coils mounted around the neck of the cathode ray tube and the position of the trace from instant to instant depends on the resultant of the electric fields produced by the application of special waveforms to the coils. Accurate off-centering for the various display areas is readily achieved by this system.

The distance between any two objects shown on the display can be measured electronically. So can the bearing between them. This facility is achieved by the use of an interscan line—a straight bright line, generated electronically, which appears superimposed on the radar map. The length and bearing and origin of the line can be varied from the control panel. Counter instruments allow range to be measured to an accuracy of 1 per cent. and bearing to better than 1 deg. The facility is of great importance in a harbour information system. Ships generally require their position in terms of range and bearing from the nearest navigational mark, rather than from the radar station itself. Also the interscan line can be used to check the position of buoys from fixed navigational marks, and to monitor dredging work.

For telephony, remote transmitting and receiving stations have been put up. Each is controlled from a control panel in Calshot Signal Station. Siting the stations half a mile apart avoids mutual interference on adjacent channels. For the same purpose the stations are put well back from the shipping lane—it passes the signal station at 1,000 ft. away.

A version of the Marconi HX/HR 80 equipment is installed. It works into groundplane folded unipole aerials on top of 80 ft. masts. Fig. 3 shows one of the stations. The transmitter gives an effective radiated power of 25 W, the maximum permitted by the Postmaster General. Crystal control is used, the six crystals of both transmitter and receiver being in a thermostatically controlled oven. The frequency stability is 0·0005 per cent. One pair of Post Office lines connects each of the five transmitter/receiver combinations to the radio control panel in the signal station. Only five pairs of lines are therefore needed for remote control.

The control panel fits in the radar control console in a way that enables more than one operator to use it. This would be necessary at busy periods, or when weather conditions make the passage of one ship occupy the whole attention of one operator.

Magnetic recording equipment is also installed. This is particularly useful during peak periods when it is undesirable to rely on manual logging. Tape is used and all three single, and the two double-frequency, channels can be monitored. A further channel records a coded time signal derived from a master clock, which is an integral part of the equipment. An additional six channels can be taken if necessary.

The recording equipment is housed in two enclosed racks. One has the recording and playback amplifiers, control units, power supply unit and the master tape transport deck. The other has the loudspeaker unit, the clock mechanism, a control unit and the subsidiary tape transport deck. The equipment works automatically for 16 hours. Should a fault occur the subsidiary tape deck takes over and a signal light is flashed. Normally a recording will be kept 30 days.

The main equipment room is under the information centre. In it the power units and the circuits for the display system are sited. The radar viewing units in the console contain a minimum of electronic units. Thus maintenance and repair work can be carried out with the minimum disturbance to the operators. The basic circuits of the display system are built in the form of plug-in unit chassis. They fit in wall frame units.

The radar aerial has a 25 ft. horizontal aperture. It is of parabolic section and slatted to reduce windage. The horizontal beam width of 0·3 deg., together with a pulse length of 0·05 microseconds, provides a good picture quality and definition. The aerial has been designed to give a sharp beamwidth at high signal strength. At 20 db the horizontal beamwidth extends about 0·65 deg. Thus, strong echoes do not greatly reduce the discrimination. The vertical beamwidth is 4 deg.

Two separate transmitters and receivers are installed, for reliability. Rapid changeover facilities are provided. The standby equipment may either be switched off, run with heaters on, or run at full power into a dummy load. The last situation allows for testing and tuning during normal operation of the working transmitter. A nominal peak power of 10 kW is used.

Auxiliary power for the station is provided by a Diesel-generator set. It is a 55kW McLaren/Brush unit, and is housed in a building adjoining the castle. When critical ship movements are taking place it is kept running. This avoids delay in an emergency.

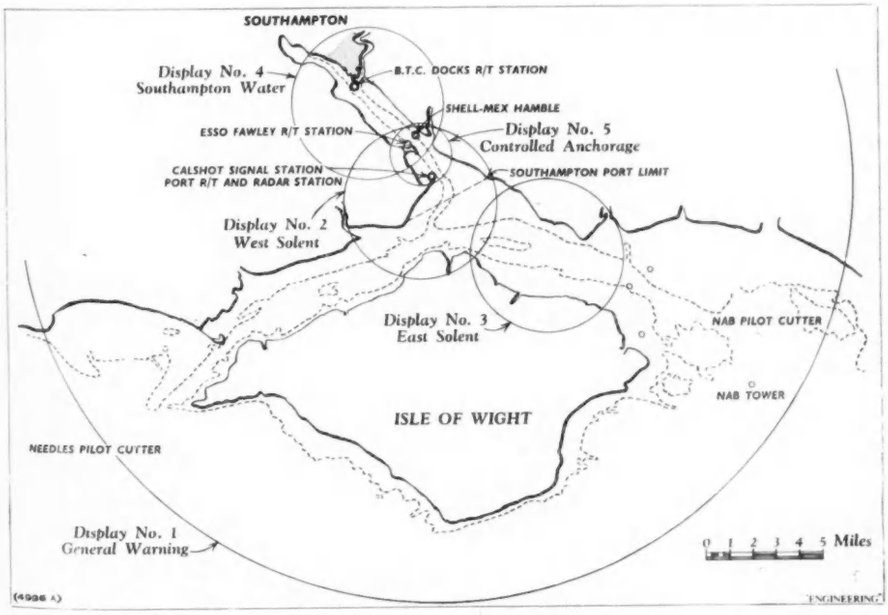


Fig. 5 This diagram of Southampton Water and the Solent shows the display areas that can be selected on any one of the three radar screens. Shore radio telephony stations are also marked.

Design

ENGINEERING DESIGN: LEARNING BY DOING

By H. Clausen

One of the main shortages in industry to-day is of good design engineers, men who can "reconcile good performance with production at an economic price." In the drawing stage, alternative constructions can be properly studied and assessed, both in general and in detail, before incurring the expense of manufacture. This argument applies equally well whether only one of a particular product—such as a special wind tunnel—is being made, or whether quantity production of many thousands is involved. The place where quality is injected into the product is on the drawing board, and the implement used for injecting it is a pencil.[1,2]

There are real difficulties involved in teaching engineering design[3,4] at engineering colleges, but although the major training must necessarily be done under working conditions in industry, the engineering colleges can help to make a start, if only in giving the graduate engineer or physicist a better appreciation of the quality and calibre of man required on the design side to balance the magnitude of the project and/or the quality of the research work.

These last words give us a clue to the design problem. Research, as such, is not taught at university or other schools any more than design is, though many higher educational establishments are more or less heavily involved in it. Research is *done* in such establishments, students working under guidance and leadership and learning by doing, as must be the case in any of the arts. Similarly, the way to deal with engineering design, another of the arts, is for the educational establishments to *do* it rather than to try to teach it in the abstract.

To a greater degree than research, engineering design must always be something of a compromise; it must be associated with a particular project, and to be completed must be carried to the manufacturing stage. Those teaching design would also have to be active practitioners of the art, as was suggested by Professor McEwen[3] and as is the case with research. Apart from the present severe shortage of competent design engineers, there seems to be no reason in principle why professional engineers in active practice should not direct and supervise design studies in engineering schools, though many points of management and administration would need to be worked out.

The value of the scientific and intellectual discipline involved in the preparation and completion of a well-worked-out report or thesis on a good piece of research work is well appreciated, quite apart from the value of the work itself. The corresponding "end product" of a design study—a set of manufacturing drawings which need no appreciable changes in detailing—involves qualities of a creative and intellectual character at a similar level, though different in kind. It may also involve responsibility for very large manufacturing costs. The value and quality of the work done is reflected in, and enhanced by, the manner of its presentation in both cases.

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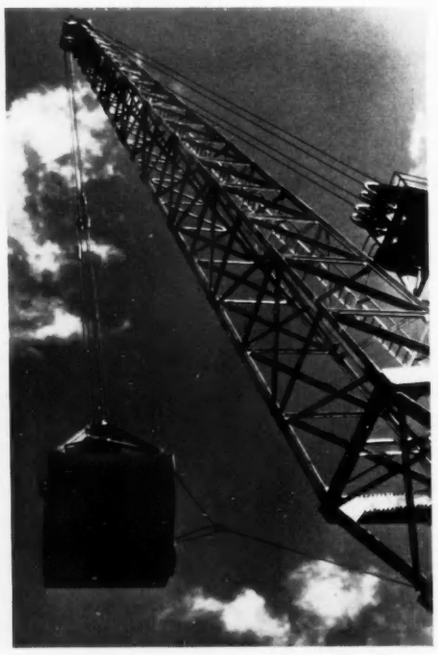
ALUMINIUM JIBS

Three aluminium-alloy crane jibs have recently been supplied by Head Wrightson Aluminium Limited, a subsidiary of Head, Wrightson and Company, Limited, 20 Buckingham-gate, London, S.W.1, to William Cory and Son. These jibs are 116 ft. long and have been fitted to 8 ton level-luffing grabbing cranes for discharging coal into coastwise colliers from ocean-going ships. As it was essential to have long jibs, the important considerations were the loading factor on the jetty and the stability of the cranes. Aluminium was therefore chosen and the complete jibs without fittings weigh 7 tons each, whereas it is estimated that similar ones in steel would weigh at least 12 tons. No painting was necessary as the two alloys used, HE30 and HP30, have good corrosion-resistant properties. The jibs will lift a nominal load of 8 tons at all radii between 23 ft. 6 in. and 96 ft. 3 in. at a speed of 300 ft. per minute. The jetty itself was described in our issue of January 10, page 47.



Aluminium-alloy construction saved 5 tons in the weight of the 116 ft. jibs.

COMMUNICATION WITH MOVING TRAINS

Experiments of Fifty Years Ago

Accustomed to long-range telephone communication with ships and aircraft, the public is surprised from time to time by reminders of the scarcity of means for exchanging messages with a moving train. This long-standing problem is still being studied, as shown by a report of trials to be carried out in the North-Eastern Region of British Railways with a V.H.F. radio link between a train and a telephone exchange. Where such facilities exist already, as on certain routes in the United States, they rely generally on an inductive link with lineside wires.

A system of this kind demonstrated in Britain nearly fifty years ago is of special interest to-day in that it provided also for warning the driver audibly and applying the brakes if he over-ran a signal. This was the Railophone, developed by H. von Kramer (a name still well-known in the electrical industry in the title of Witton-Kramer Limited) with the collaboration of Dr. Gisbert Kapp, Professor of Engineering at Birmingham University. One contemporary report of a Railophone demonstration near Stratford-on-Avon in 1911 describes the trains as travelling through an "ethereal inductive tunnel" (that is, the field surrounding an insulated cable buried several feet away from, and parallel with, the track). The field was produced by audio-frequency currents for telephone communication, or by single-phase alternating current at 100 c/s for automatic train control, and induced corresponding currents in receiving coils mounted on the guard's van of the train.

Apparently the Stratford-on-Avon demonstrations were convincing, for another commentator warned von Kramer of undesirable consequences if his ingenuity removed too much responsibility from the engine driver. This argument, with its accompanying misgivings over the expense of such a system, is still familiar when the extension of automatic train control is discussed.

Another foretaste of present-day methods was the invitation to Marie Corelli, the novelist, who lived locally, to speak on the Railophone during the demonstration. Evidently the art of public relations was already studied, even if its practitioners had not by that time multiplied to the numbers which led to public relations officers being described the other day as "the army which knows no 'other ranks'." The future for audio-frequency inductive systems seems less hopeful, for with a high-voltage contact wire carrying 50-cycle alternating current along electrified main lines, communications and signal engineers will be occupied with inductive problems of a different kind.

SAFETY IN ATOMIC ENGINEERING

At the present time there is a good deal of publicity, not all of it favourable, about the safety measures taken at the nuclear reactor at Windscale before the recent accident. It is only fair therefore to draw attention to the remarks of the Chief Inspector of Factories in his latest report. The *Annual Report of the Chief Inspector of Factories for the Year* 1956 has a section in its first chapter on safety in the nuclear power stations. The report is of course a year out-of-date as always and the Windscale incident had not happened when the report was prepared, but the high praise of the Chief Inspector for the safety measures at Calder Hall should be noticed.

The report says that "it must be said here that the first nuclear power station is also a triumph in safety engineering." The report then goes on to point out the care which was taken by engineers, metallurgists and control experts on the design and control system worked out for the Calder Hall reactor. The report draws attention in some detail to the advantages from a safety point of view in using the natural-uranium graphite system and upon the development of a magnesium alloy as a material for fabricating into gas-tight containers to seal off uranium fuel elements and prevent them spreading throughout the gas system and contaminating the heat exchangers, fans and ducting. Some description is also given of safety measures used in the use of neutron-absorbing material and on the care taken with biological protection from reactor core radiation. It is of course worth mentioning too that, as distinct from the Windscale piles, the reactors in use at Calder Hall are cooled by gas flowing in an entirely closed circuit.

BOOSTING HELICOPTERS

We give below a summary of a lecture on "Boost Systems for Helicopter Gas Turbines," given recently in London by Dr. A. W. Morley, of D. Napier and Son Limited, before the Helicopter Association of Great Britain.

The single-engined helicopter requires a much bigger engine for take-off than is necessary for cruising flight. In the twin-engined helicopter, which is required to fly safely on a single engine, unless the engines are oversize for take-off, more power is required to fly comfortably with one engine out of action than the remaining engine can stand. Generally, extra power is required for a minute or two only; for example, to clear local high ground; to enable a manoeuvre from hovering flight into a comfortable cruising condition; or to make a safe take-off and landing.

If it were possible to boost the engine power for short periods, the operator would then be able to accept bigger loads, guarantee satisfactory performance with one engine failure, and not be affected by the loss of engine power which occurs on a hot day.

Considering only gas-turbine power units—since these will be the helicopter engines of the future—there are four likely methods of power boosting: (*a*) the rocket-on-rotor system which uses small rocket units at the rotor blade tips, such as the Napier "cold" hydrogen peroxide rockets used on the Saunders-Roe Skeeter helicopter and under consideration for the Westland Whirlwind; (*b*) where there is provision for a gas drive to the rotor tips, boosting can be obtained by after-burning more fuel at the tip jets; (*c*) where the rotor is mechanically driven, the power can be boosted by increasing the output of the main engine for a short period; (*d*) an auxiliary gas-turbine can be brought into operation to meet conditions otherwise too severe for the main power plant.

The essence of method (*a*) is its simplicity. A potential advantage of method (*b*), boosting by tip-jet burning, is that there is no sudden change in torque reaction even if the boost is very rapidly applied, and no loss of effectiveness due to the need to supply power to an anti-torque propeller. This method of boosting requires a power plant which can supply a considerable air bleed at short notice. It also requires special ignition equipment. The air bleed to the rotor tips would either have to be permanently on or available immediately. When the emergency arose, the rotor fuel and igniters would have to be switched on to provide the extra rotor power without delay. Clearly, such a system would have to be fully automatic.

Method (*c*), which involves an increased compressor speed and heat flow through the whole turbine, is effective provided that the turbine does not overheat excessively, but in a single-rotor machine it does demand an increase in the anti-torque power. Some of these complications might be avoided by a combined system in which the normal power to the rotor is by mechanical drive while the boost power is by pressure jet to the rotor tips, supplied from a separate boost compressor. Method (*d*) appears to add undesirable complications.

The rocket-on-rotor system probably has the greatest power potential and calls for the minimum of modifications to the existing power plant and airframe. It is likely to be heavier if more than a very short endurance is required, due to the voracious appetite of the rocket engine. For the same installed weight, including fuel, the endurance of the various turbine arrangements would be several times greater.

A composite pressure-jet mechanical-drive system using an auxiliary compressor clutched into the remaining "live" engine has a high potential output without imposing any more load on the live engine. In such an arrangement the ultimate amount of boost is obtained when all the power of the live engine is absorbed by the auxiliary compressor, and the compressed air is heated in the tip units to the highest possible temperature.

Boosts of the order 40 to 50 per cent. take-off power should be available with a gas-turbine shaft drive, by over-speeding combined with water injection. With a twin-engined machine which suffers an engine failure, the final transmission is not overstressed by boosting. The engine and its gearbox are overloaded, but the weight penalty is small and there are no difficulties with the installation. If water injection is not used, one would expect to find a lower safety margin on the turbine blade stresses. Nevertheless, it is simpler to avoid the use of water injection and, therefore, preferable to develop the engine to the necessary standard of reliability without it.

In comparing the endurances of the various systems for a comparatively heavy weight of fuel, water or propellent, the straight uprated hot turbine, with its low specific consumption, has a clear advantage. The same engine using spray cooling of the turbine has less endurance, due to the additional water consumption, but the turbine itself will have an improved life due to its lower metal temperatures. The use of an auxiliary gas-turbine to boost main engine power has a somewhat shorter endurance than the "hot" turbine engine because of the latter's better specific consumption. The composite gas-turbine and pressure jet system is an interesting possibility, giving an endurance time intermediate between that of the rocket-on-rotor and which is something of the straight uprated mechanical-drive turbine.

NEW BRITISH STANDARDS FOR ELECTRIC CABLES

Modern Manufacturing Methods Lead to Material Economy

For some time a sub-committee of the British Standards Institution has been considering a new specification (B.S. 2899 : 1958) dealing with the composition and performance requirements for the insulation and sheaths of rubber-covered cables. This new specification is based partly on recommendations made by the Commonwealth Conference on Standards for Electric Cables, which was held in London in 1953, but is also intended to take advantage of modern manufacturing processes.

Mr. B. B. Evans, who is a member of the sub-committee, points out that the new specification covers the composition and performance requirements of three types of insulation—general purpose vulcanised rubber, fire-resisting and ozone-resisting; and four types of sheath—general purpose and heavy duty rubber and polychloroprene. It will obviate the necessity of including particulars of composition and test clauses in the other cable specifications and therefore of having to issue individual amendments to them.

One important change is that the rubber content of compounds will be specified by volume instead of, as hitherto, by weight. This is logical since during manufacture the compounds are applied in specified thicknesses to lengths of conductor. As the result, too, of operating experience under a variety of climatic conditions the rubber content of the compounds has been reduced from 70—75 per cent. to 50—60 per cent. by volume with a corresponding reduction in the minimum tensile strength to 1,250 lb. per sq. in. The requirements for ageing resistance, however, remain the same as in the 1953 specification. The insulation resistance for the factory test, which is normally made within 48 hours of the vulcanisation of the rubber-insulated core has also been reduced by 25 per cent. without, investigations show, increasing the risk of mechanical damage.

The new specification contains physical, ageing and other tests for controlling the quality of the composite fire-resisting insulation which consists of an inner layer of vulcanised rubber compound and an outer layer of vulcanised polychloroprene compound. A resistance test for ozone-resisting insulation has also been included. On the other hand, the only practical difference between the sheath requirements in the 1953 and the 1958 specifications is that less rubber is required and that the minimum tensile strength has thus been cut to 1,200 lb. per sq. in.

Now that vulcanisation is carried out by a continuous process it is questionable whether the tape traditionally used to support the unvulcanised cores is necessary. Both laboratory and field tests, in fact, showed that tape could be omitted from conduit-wiring cables without detracting from their resistance to installation hazards.

Dealing with future trends Mr. Evans argues that now that rubber technology is approaching an exact science many technologists believe that it should be possible to dispense with composition requirements and to frame a specification consisting only of performance tests and requirements so framed that any "rubber" insulation meeting them must necessarily be of satisfactory quality. This type of specification would allow manufacturers more flexibility in the choice of material and be important in obtaining a measure of price stabilisation. The Cable Makers' Association is therefore conducting experimental work with the object of framing proposals for a British standard based purely on tests and performance. This would ensure a satisfactory product while allowing manufacturers the economic choice of natural or synthetic materials.

SLURRY FIRING

The Barony power station in Ayrshire, which was opened in October last, utilises washery slurry for its fuel supply. This material is counted to be the lowest grade of residual fuel, but is satisfactorily burnt in the four Babcock and Wilcox boilers which have a maximum continuous rating of 150,000 lb. per hour each. The slurry has a gross heating value of 6,450 B.Th.U. per pound, a moisture content of 30 per cent., ash content 25 per cent. and a grading that includes 95 per cent. through $\frac{1}{16}$ in. mesh standard sieve.

The difficulties in handling such fuels have been overcome by the use of rotary fuel hoppers from which the slurry is discharged by means of a stationary plough. It is fed on to a belt conveyor in the same manner as graded coal is fed from a standard bunker with a vibratory feeder. The main design of the hopper, which has a conical shape with sides sloping inwards towards the top, is that the body itself is mounted on heavy roller tracks and is free to rotate, thus avoiding the continuous shearing action which would otherwise take place between the sticky slurry and the hopper sides.

From the hoppers the slurry passes to a mixer house which enables different grades to be fed from different hoppers and mixed in any desired proportion before being passed to the boiler house. The mixing stage can be by-passed if desired. The next step is to the boiler house where the slurry is transferred by a reversible shuttle conveyor to one of the boiler hoppers. These are also of the rotary pattern, but considerably smaller in size than the main hoppers of the coal store.

As the slurry cannot be tipped from the rail trucks in which it arrives at the station, it is grabbed out of the wagons by 4 ton Goliath cranes and transferred to the main store. A certain amount of slack is also kept in the store and is handled in the same way as the slurry.

Engineering at Home

ELECTRONIC MUSIC

Waves of compression and rarefaction reach our ears and we hear sound. The waves originate from a mechanical vibration: in the vocal chords, the reed of an oboe, or the diaphragm of a loudspeaker, for example. Sometimes the sound merits the label "music." It depends on the listener. All of the vibrators mentioned can produce music. Clearly there is some difference between the first two, and the loudspeaker. The last is very often the means whereby the first two are heard. Its great advantage is that it is driven electrically and not mechanically.

Being driven electrically, it can be used to reproduce the same sounds as often as required; the electrical waveforms that drive it can be stored indefinitely by various means—magnetic tape, film, etc. It can also produce sounds that would otherwise have no existence. Electrical waveforms can be generated electronically and fed to the speaker which transforms them into "artificial" sounds. An analogy can be drawn with the operation of the vocal chords: they are set in motion by a train of nervous impulses from the brain. The speaker is set in motion by a train of electrical impulses from a generator. In most cases the engineer has more control over the vibrations of his loudspeaker than the singer has over the vibrations of his vocal chords.

Until quite recently the main effort in loudspeaker reproduction had been concerned with reproducing sounds that occur "naturally." Even to-day few engineers exploit the possibilities of electronic equipment to generate music. However, interest in this field is growing and recorded musical works that have never been performed, except on a gramophone, are now available. The ballet music "Cain and Abel," for example.

In an article "Electronic Music," the composer Henk Badings and his colleague J. W. de Bruyn, of Philips Research Laboratories, Eindhoven, describe the electronic aids they used to realise the score of the ballet. The article is published in *Philips Technical Review* (vol. 19, No. 6, 1957-58). Fig. 2 shows the equipment used.

Electronic engineering enters into the creation of electronic music in three ways. It gives new sources of sound, it makes it possible to transform sounds, it governs the reproduction of the music. A new freedom with which a sound source or sources can be arranged in space is given. It is possible to produce all transitions between the clear and dry directional sound of a trumpet in open air, and the diffuse sound of choral music in a church.

The volume control is another powerful influence. With it dynamic figures can be introduced in notes, or combinations of notes, where this would otherwise be impossible. Fixed relation between timbre and intensity can be removed.

When the sound is reproduced via the medium of magnetic tape even greater control can be got. The conductor or composer has the music literally at hand from second to second and can do what he wishes with it. Speeding up the tape produces new tonal patterns and also makes it possible to play very fast runs quite beyond the reach of a flesh and blood musician. Continuously varying the speed of the tape results in a glissando. The tape can also be played backwards.

Other ways of transforming sounds are electrical filters, which can bring in variable linear distortion, and the modulator. The latter has two pairs of input terminals. If two musical tones are applied, both appear at the output with all their combination tones (intermodulation products). Reverberation can be achieved with various kinds of electronic delay.

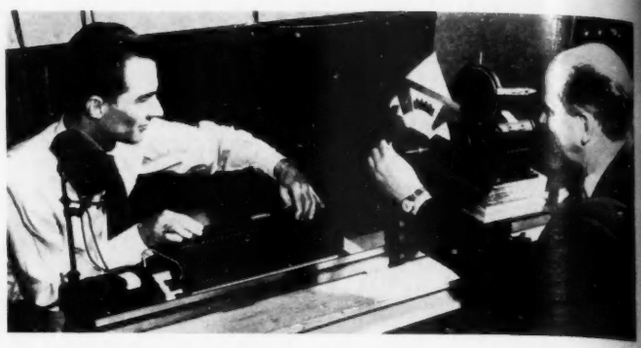


Fig. 1 The composer can draw the waveform of any tone colour he wants and generate it on the optical siren at any pitch.

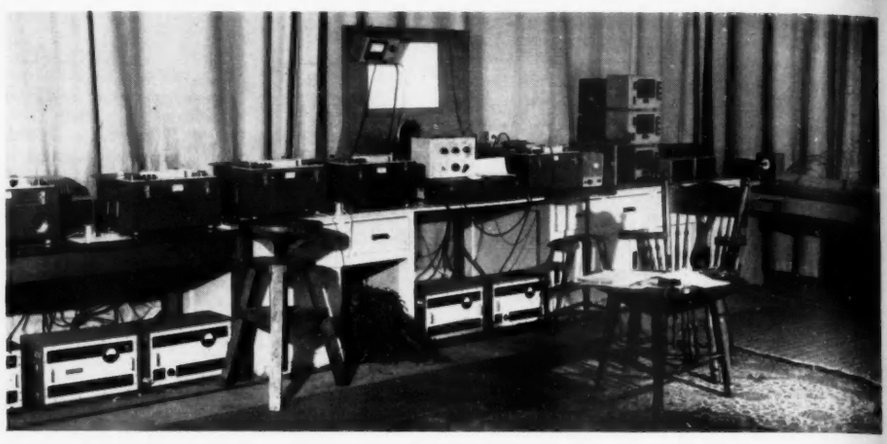


Fig. 2 Part of the equipment used to make the ballet music "Cain and Abel." Some of the seven tape recorders used can be seen and also various amplifiers, a mixing desk, filters, etc.

The simplest electronic source is the sine wave generator. It produces a tone through the loudspeaker that is practically devoid of harmonics. With it one is able to depart from the narrow paths of the conventional equal temperament scale, which divides the octave into twelve equal intervals, and in "Cain and Abel" repeated use is made of pure (harmonic) intervals. These are intervals exactly equal to the whole-numbered frequency ratios of the harmonic series. Intervals with ratios 7 and 11 were used. These have no counterpart in European music.

As alternatives to sine waves, sawtooth, trapezoidal, or square waves can be generated. They can then be shaped by filters if desired. The white-noise generator is another electronic generator. Such noise has a constant energy distribution across the entire audible spectrum and is not in itself musically interesting. However, wide band filters can give it a vague impression of pitch.

In the electronic sources so far mentioned, the frequencies are determined by electrical elements. There is another group of instruments in which the frequency and tone colour are determined by mechanical means, but they only become acoustically effective through the loudspeaker. Condenser microphones can be used as electronic "drums" by tapping the diaphragm. An alternative type of drum is the large sheet of steel with a piezo-crystal fixed to a particular part of it: according to the part struck and the manner of damping the vibrations, a great variety of sounds can be produced.

A particularly interesting instrument is the one the authors call the optical siren. Fig. 1 shows them using it. A beam of light is focused on a photomultiplier tube. Situated in the beam is a holder that contains a sheet of paper with the shape of a waveform cut out in it; behind it a disc rotates. Narrow radial slits in the disc scan the pattern, and the light falling on the photomultiplier varies in accordance with the pattern ordinate. The disc speed determines the pitch and the pattern sets the tone colour.

Outwardly the most striking difference between electronic and conventional music is that the former cannot be performed by musicians in the presence of the public. The composite sounds that the composer indicates at a given moment in his score are each produced separately. The result is a number of acoustic layers, each recorded on a separate magnetic tape. Tuning control by means of fixed frequencies and accurate time measurement ensure that the acoustic layers are properly matched and synchronised. The layers are then put together in the correct dynamic relationship and the tape is ready to be played in public. In the same way that a painter builds up his picture so the composer can build up a symphony. Electronics gives him a palette of sound.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

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